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VOLUME XI.

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ANGLING CLUBS. (*J. Skinner.*)

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THE PROPAGATION OF THE SALMONIDÆ.

"*AS A MAN SOWETH SO SHALL HE REAP.*"—[J. STIRLING.]

THE PROPAGATION OF SALMONIDÆ.

THE reproduction of any species of fish or animal may be left to the resources of nature, or it may be cared for and aided by man. Natural propagation must always be the principal source from which the stock of our large rivers is replenished, but it may be supplemented by art, while in some lakes artificial stocking may be the only source. When the fish and ova are left to nature the eggs and fry are exposed to innumerable dangers. Fish may be deterred by obstructions from ever reaching suitable spawning-ground; much of the ova may never be fecundated; after the ova has been deposited and the milt has been shed upon it it may be scattered by a flood, or left dry in a drought, covered up with a deposit of mud, destroyed by the water-shrimp or the larvæ of the May fly, or it may be consumed by ducks, geese, swans, kingfishers, and other birds. After the little fish leaves his first home he is constantly preyed upon by numerous enemies, and while he is still a few weeks old, most of the enemies, just mentioned, keep up hostilities, and indeed, some of them, such as swans, never cease their persecution till years have so added to the size and wariness of the fish as to make capture by the beak of a bird impossible. Pollution affects the health of young fish and kills them off more easily than old ones. It has often been observed that small trout and parr are killed by a discharge of poison, when old fish, say of a pound weight and upwards, were not affected ; the organs of the young fish, as of the young person, being more susceptible of anything abnormal. Throughout its whole life a fish is more constantly exposed to danger than any land animal, but throughout its youth a young salmon or trout has so many difficulties to contend with that if it had not been provided that each adult female should annually deposit an almost incredible number of eggs the species would soon become extinct. It may be calculated that a salmon will lay 1000 eggs for each pound of its weight, and it has frequently been stated by weighty authorities that the number of eggs which become mature fish does not exceed one in a thousand.

By the exercise of care man cannot entirely exclude danger, but he can diminish it so much that the number of fish reaching maturity will be enormously increased. If the supply of the salmonidæ for our markets is to keep pace with the ever-increasing demand something must be done in the way of assisting nature, and it is by means of artificial propagation that this object can be accomplished.

Britons generally pride themselves on the fact that they have led the van in all great arts. The art of pisciculture is an exception to the rule, for in it they have brought up the rear. Most of the great states directed their attention to it many years ago. At Huningue the French Government erected, in 1852 and 1854, a fish-breeding establishment at a cost of £10,607, and it was carried on from 1852 to 1863 at a cost of £13,887, or an annual cost of about £2000. I have no recent statistics of the work done by this establishment, but I find that in 1861 from 19,449,000 ova collected, 16,244,050 after being " eyed " were " forwarded in a sound state to upwards of 238 different places to be deposited and incubated." It is further stated that the proportion of the eggs collected which become living fish may be taken at one-third; if the salmon and trout eggs alone are taken into account a larger proportion are successfully hatched. It is hardly necessary to say that the distribution of such quantities of ova is having the desired effect, many French streams being now well stocked which were formerly barren.

In Russia, generally considered so far behind the rest of Europe, there are several enormous fish-hatching establishments maintained at the expense of the Government.

In the countries on the other side of the Atlantic perhaps even more has been done towards making a practical use of the science of pisciculture. In 1853 Dr. Garlick of Ohio first propagated fish in the States by artificial means; the subject gradually attracted the notice of the Government and of the public, and in 1868 the rivers and lakes in the State of New York were examined by a Commission, with a view to their being stocked with fish by artificial propagation, and in order to ascertain what kinds of fish were suitable for introduction into waters to which they were not indigenous. The same State now spends £3000 annually in maintaining and improving its fisheries. As an example of the good work done by the Fishery Commission of the States it may be mentioned, that at their station on the McCloud River, in one season, 9½ million eggs of the Quinnat or Californian salmon were taken, of these one-fifth were returned, when partially or wholly hatched, to the rivers whence they were taken, the remainder being distributed throughout the States. On the same river a hatchery has recently been erected capable of bringing out 6,000,000 eggs of the Californian mountain trout. The shad, a sea fish, which in some respects resembles the common herring, but like the salmon spawns in fresh water, the shoodic, the black bass, and many other delicate and valuable fishes have engaged the attention of the Commission, and the result is that these fish, as well as the carp, an importation from Europe, are found plentifully in many localities where they were formerly unknown.

In Canada there are no fewer than eleven hatcheries under the superintendence of the department of the Minister of Marine and Fisheries. During the year 1882 there were laid down—of the eggs of the salmon, 6,612,000; the salmon trout, 8,350,000; speckled trout, 200,000; white fish, 43,000,000; in all, 58,162,000; and there were distributed throughout the spring a total of 55,799,000 fry.

Although our Government has not yet taken up the subject and assisted the science of pisciculture by a pecuniary grant, as it is to be hoped they will soon do, we may congratulate ourselves that the matter has been dealt with so energetically by private enterprise, and that the efforts of many parties have been attended with great success. Already it is common for proprietors and clubs to purchase a stock of eggs and fry annually, and doubtless, when it becomes more widely known how profitable this stocking is, such means of replenishing nature's stores will come into general use.

To state as concisely as possible the method of obtaining the eggs and milt from the parent fish and the conditions necessary for their successful development will now be my object.

Before proceeding to secure the eggs one must make sure that the hatching apparatus is in order. The first requisite is a current of pure water—this need not be of any great power, an ordinary half-inch tap, such as we find in houses, is sufficient. Spring water, as it is the least likely to vary in temperature, is the most suitable; the best temperature being between 40 and 45 degrees. The purer the water is the stronger will the eggs be, and for this reason filtering the water before it comes into the hatching-trough is very desirable; sand, charcoal, or any other suitable filtering material may be used. Notwithstanding filtration, a deposit may be found to accumulate in the troughs, which is most injurious to the eggs by preventing their getting the necessary supply of oxygen, and favouring the growth of fungus. Mr. Buckland, in his work on fish hatching,* pointed out a simple and fairly effective method of obviating these evils, viz. by keeping the boxes dark, which will help to kill all vegetable growth, and by putting slates over the eggs, which will collect any sediment as it settles.

The boxes in which the eggs are laid may be of wood, slate, or several other materials. Zinc, being too subject to the chemical action of some waters, is not so suitable. They may be of any size desired—four feet long, eight inches broad, and six inches deep is a convenient size. The boxes are arranged on steps one above another, so that the same water may be utilised to flow through all. There should be a crane on the pipe where the water flows into the boxes, so that it can be turned off and on at pleasure; if the boxes are wooden, a small piece of lead piping is often inserted, by means of which the water will flow from one box to another. A piece of zinc, finely perforated, must be placed closely over the openings from one trough to another, and over the hole through which the water escapes from the lowest trough, as the little fish, when hatched, have a very strong inclination to work their way

* Tinsley Brothers, 1863.

down stream, and will make efforts to get through the smallest aperture. It is desirable to have the boxes some distance above one another, as the slight fall between each helps to oxidise the water, as falls do upon rivers; if the water is made to fall upon a saucer, instead of directly into the trough, it will be still better aërated.

The eggs may be laid on gravel, glass rods, or trays made of wire netting, very small in the mesh; the latter is much used in America, but in this country the glass rods have received most favour. If gravel be used, it should be about the size of peas, and before being put into the boxes it ought to be boiled, and afterwards washed, so that it may be free from any organic germs. Mr. Buckland advised that first a layer of small gravel be put down, and on the top of it stones about the size of walnuts, among which the eggs should be sown; but I do not think the layer of large gravel is generally approved; its disadvantages are that dead eggs may not be easily seen, and, if seen, it may not be possible to get them out without disturbing other eggs—two points of great importance.

The hatching apparatus being all in order, one must be on the outlook for occupants for it. Eggs may now be bought partially hatched, or, as they are called, "eyed," from several piscicultural establishments in this country. This is a great boon to many who have not the opportunities for securing eggs otherwise. The eggs generally come from the dealers packed in moss, and they must be very carefully freed from any particles of it before they are set in the troughs; this is easily done by immersing them in water, as the eggs will then sink and the moss will float. As sudden changes of temperature are injurious to the eggs, the barrel or tin in which they are packed should be placed in the water before transferring the eggs to the troughs, so that the change may be gradual. In transferring the eggs from the vessel in which they are washed to the troughs, a glass tube should be used. This is an admirably simple device, and the use of it is easily learned. When an egg is to be lifted the thumb is placed over one end of the tube, and the other end is placed close to the egg; on the thumb being lifted the egg goes into the tube. In spreading the eggs upon the glass rods a feather or hair pencil can be used.

Most of those who have the wish and the opportunities to hatch will also be in a position to obtain the eggs direct from the parent fish. Where it is practicable, gentlemen who aspire to be pisciculturists should not grudge the little extra trouble in taking the eggs, as it is certainly more satisfactory when one's fish come out to know that one has not only cared for and tended them, but also taken them from the old fish. The methods of doing this will now be described.

The time when fish spawn varies by months on different rivers, and it may sometimes be delayed for weeks by floods. One must be on the outlook as the time draws near; and as the fish come into very shallow, clear water for the purpose, no great difficulty will be had in knowing when to take them. The female may be seen, attended by one or more males, shovelling up the gravel by the action of her tail. To capture the fish a net must be used. When in skilful hands a large landing net, square on the side farthest from the handle, may be sufficient, but after one or two fish have been taken, the others in the shallows are apt to be scared and retreat into the pools. To obviate this a net should be placed across the stream, both above and below the place where the fish are lying; a double net, such as is used on the Solway and in some parts of England, will be found very serviceable; one of the nets has a very large mesh, the other is small and light; the fish rush first against the small net, and carrying it with them through the large one are suspended in a bag.

As the fish are captured they are put into a tub or other vessel. Their sex, and whether they are ripe or not, is then to be ascertained. The male trout when spawning has a slight horny projection on the lower jaw, not nearly so defined as the hook on the male salmon at the same period, but still perceptible. Apart from the formation of the snout, however, there will be no difficulty in knowing the sexes, as the ova will be felt quite easily in the belly of the female, and if the fish are ready for stripping, some of the ova, or milt, is sure to come away on the slightest pressure. One may proceed to strip the females if the males are not in a smaller minority than one to three, as the milt of one male will fecundate the ova of three females. One person should not attempt to take eggs from the fish, as during the process they require to be held steadily, yet without any undue pressure or roughness, consequently assistance is always desirable. The vessel best suited for receiving the eggs is an earthenware pudding dish. A female fish is first taken from the tub or tank where the captives are, it is held over the dry vessel in the left hand of the one person, by the head, another holding it steadily by the tail. The thumb and forefinger are then put round the belly of the fish where it joins the breast, and with a gentle pressure are moved along towards the vent. If the fish is ready the eggs will drop out one by one. It is not an uncommon method to remove first those eggs nearest the vent, and thereafter those next the ones removed, and so on, taking the eggs out in batches till the ones nearest the breast are removed. It is, I think, immaterial which method is adopted. After the females have been stripped of their eggs a male is taken and handled in the same way, when his milt will drop into the vessel beside the roe. Thereafter a small quantity of water is poured gently into the vessel, and it will in a few seconds become of a milky hue. The water may be slightly stirred so as to bring all eggs into contact with the minute organisms of the milt. After standing half an hour the eggs will have been fructified, the milky-coloured water may then be removed, and clean water poured upon the eggs and off again. After this they are ready to take home to the hatching troughs. A cloth, or cloth glove, should be put over the hand holding the fish, as thereby it is prevented slipping.

Instead of pouring in water after both the ova and milt have been taken from the fish, water may be poured upon the ova, and the male may then be stripped into the water. But if this method be adopted, the milt must be shed within twenty minutes after the ova.

The first of these methods is termed dry spawning, the second is only partially dry; they are the methods now in use in this country, the first being by far the more general. There is still another way, however, which, though it is old-fashioned, it may not be amiss to describe briefly here.

Instead of the dish being dry to commence with, it is filled with water, and the roe dropped into the water, the milt is then shed into a separate vessel with water, this water and milt is poured into the vessel containing the ova, and thereafter the whole is gently stirred for a few seconds. The objection to this method is that the roe after it has been immersed in water for about twenty minutes loses its power of receiving the spermatozoa of the milt. These spermatozoa, on the other hand, when they have been ten minutes in water without coming into contact with an egg, become inert, and lose their power of fructification.

It is better to convey the eggs home in a pitcher containing water rather than dry, as if in water they can be lifted by the tube, whereas if dry they are generally lifted by the fingers, which to eggs newly fertilised is very injurious.

Arrived at the hatching house, the eggs are laid down in the troughs on the gravel, glass grilles, or trays, whichever may have been selected.

Crowding eggs in the boxes must be carefully avoided, no two eggs should touch one another, so that as much as possible of the surface of each egg will be exposed to the current of the water, and so that if one egg should die, the fungus which at once will attack it will not be so likely to spread to the others.

The eggs must be carefully examined each day, and all dead ones removed.

As already mentioned, the slightest sediment is injurious to the eggs, depriving them of their necessary allowance of oxygen, and often covering them with a vegetable growth, consequently the water must be kept perfectly pure, where it is not naturally so, by means of the filter. Even the exercise of the greatest care cannot at times keep the fungus away, but if the eggs have been properly vivified, if the filter be attended to, and if the boxes be kept dark, the loss from disease will be very small.

About six or seven weeks from the date when the eggs were laid down the eyes of the young fish will become visible through the shell. The egg can now be moved from the trough and sent long distances packed between folds of muslin and layers of damp moss carefully washed. Although the vitality of the embryo fish is now greater, it will be found advisable to increase the flow of water after this period.

Of late years the practice of sowing out eyed ova in artificial redds has become very general. The method has great advantages, as since eyed ova can now be purchased so cheaply, no hatching-house is necessary. The eggs, having been partially hatched inside, are laid down on redds formed in or at the side of the stream with boxfuls of gravel; if at that stage the eggs required the same purity of water as is necessary for their development during the first few weeks the system would not have been so successful; fortunately they do not. The best redds are those where spring water is used. The water may be led from the spring in a pipe, under ground if possible, to prevent freezing; and before the water reaches the redd a pool or pond may be constructed to let sediment settle. The redd may be constructed in several ways, a long trench or box with the water running along it, not across it, will be found most convenient to examine. The bottom is laid with gravel, and the eggs are scattered on the gravel not more than 1000 to two square feet. A connection is made with the main stream, and the natural inclination of the fry when they hatch out soon makes them descend. Spring water is not absolutely necessary, and is often not obtainable; if a small stream is at hand the box and ova may be placed in its bed, but in that case there should be at least two inches of gravel on the top of the ova. Hatching boxes, outside as well as those in the house, should be covered with lids.

The time eggs take to hatch out varies with the temperature, the colder the water is the longer they take. No anxiety need be felt so long as the eggs are healthy-looking, as the longer the fish take to form the stronger will they be.

If glass grilles be used, the fish, when they come out, will drop through the openings into the water beneath. At this period the boxes should be frequently examined, as one may save many fry by assisting them with the hair pencil to leave the shell; the empty shells should be picked out.

The alevins, as the young fish are called before they begin to feed with the mouth, may be let or lifted into a box separate from the unhatched eggs, or if they are not overcrowded and the flow of water is increased they may be left alone. The umbilical sac, which is easily seen hanging from the belly of the little fish, will be absorbed in from five to eight weeks after hatching. During the first three or four weeks the alevins will be observed crowding into the corners of the boxes as if desirous of hiding under one another; some breeders recommend that stones be put in, under which they will go at once, but even there the same pushing and wriggling seems to go on. The stones, or what is better, stones with pieces of slate laid on them, will be much appreciated after a week or two. When the yoke sac is about half absorbed the young fish get lazier, they scatter more about the box and lie almost motionless. When the sac is almost exhausted they regain their activity and will be seen swimming, or at least endeavouring to swim, in the strongest part of the current. If they are to be confined in the house any longer they will, at this stage, require to be fed. Opinions differ as to what is the best food. Small blood-worms which are found in the mud of some English rivers are good fare, also midges or gnats where these can be caught. The latter seem to be the most nutritious, and if practice makes proficient this food teaches the young fish to rise well. Many years ago Mr. Buckland said that trout and salmon fry might be fed on the roe of a sea fish, such as the sole, the peas being small enough for the mouths of the fry; the suggestion was a valuable one as it is both a clean and nourishing food. They will also eat, greedily, boiled liver grated small; care must be taken, especially when liver is used, that the food does not fall to the bottom and there putrefy; to prevent this a small tray may be sunk in the trough upon which to feed the fish. After the fish have been feeding about six weeks raw meat, finely chopped, may be given them.

When the fish are about three or four months old, breeders generally turn out the most of their stock into the streams, where they shift for themselves. As they require a daily increasing space, it is generally necessary to get rid of some of them. A shallow streamlet or burn should be selected, the depth varying from six inches to two feet, with plenty of shelter in the shape of stones, old drain-pipes, &c. If practicable, the stream where the fry are put in should be cleared of large fish, as they come into the shallows in the evening and are very deadly to the fry. Herons, gulls, ducks, and swans should also be kept away as much as possible. As the fish grow older they drop down stream till the water is of a suitable depth.

When the fish are turned out, artificial feeding becomes of course unnecessary, as any stream of a temperature above 47° will contain food sufficient for the fry.

Although the breeder must part with most of his fry when they are but a few months old, it lends additional interest to the art if a few are kept in ponds. There is no difficulty in this, other than in providing a sufficient supply of water, plenty of space, and plenty of food. With these conditions fulfilled, trout will thrive and grow fat in confinement, and may be so kept all their lives.

In the case of the fry of the salmon and the other migratory species of the salmonidæ, the ponds they are kept in must have connection with a river. When they are about fifteen months old it will be observed that many of them assume a silvery appearance, that is their sea-going costume; the sluice at the outlet of the pond must now be lifted, and it will be found that about one-half of each brood of parrs having become smolts are impelled by instinct to leave the ponds and descend into the river on their way to the ocean.

As so many acres of land will only support a limited number of cattle, so the capacity of even the best feeding streams and lakes is limited; and when we resort to artificial stocking, we must not fall into the error of introducing more fry than can find food. The mistake has been frequently made. In nature we see the same point illustrated. Many lochs in the Highlands of Scotland, which to appearance are well calculated to sustain numbers of good trout, are tenanted by multitudes of poor thin little fish, and it has been noticed that when such lochs are regularly fished the quality improves.

It must also be borne in mind that some waters are naturally more fertile than others; the altitude of the stream or lake, the nature of its bottom, the presence of minnows, freshwater shellfish, caddis-worms, and even certain water plants, with many other circumstances, affect its fish-bearing capabilities. A stream may produce many salmon which is stocked with few and inferior trout; this is easily understood, as the growth of the salmon after the smolt stage is entirely in the sea, and all that is necessary for them is an uninterrupted course to good spawning grounds.

The title of this essay is the Propagation of the Salmonidæ, and I have directed my attention solely to propagation by artificial or semi-artificial means. But we must not forget the incalculable value of the natural method of reproduction, and we must make every effort to make it possible and successful. Hitherto we have in general done the reverse; we have rendered spawning of the salmonidæ in many stretches of water impossible. Apart from pollution, so disastrous as to annihilate every vestige of animal life in many rivers, we have poured into others sewage to an extent which, though not sufficient to cause the death of old fish, is enough to prevent the eggs and young from coming to maturity. We have built weirs on almost all our salmon rivers, under which the poor fish lie faint and diseased, or they cut and bruise themselves in the efforts to ascend, which nature compels them to make; where we have put ladders they have too often violated every principle of success.

When we consider the treatment to which our freshwater fisheries have been subject, the fact of the salmonidæ being as plentiful in Great Britain as they now are, is a matter for surprise; but if man has been obstinately foolish, nature has been wise and beneficent. It is not too late for us to strike out a new path, and the people of these islands may congratulate themselves that the public interest and the public conscience at last show signs of awakening.

THE PROPAGATION OF THE SALMONIDÆ.

"*LABORUM DULCE LENIMEN.*"—[T. ANDREWS.]

THE

PROPAGATION OF SALMONIDÆ.

In consequence of the declining yield of a great number of rivers and lakes, not only in Great Britain, but in other countries, as well as the ever-increasing demand for salmonidæ, propagation by artificial means, or protected breeding, has become an acknowledged necessity. Whilst it is believed that some waters continue to yield as abundantly as in former years, it is also well known that the annual produce of others has considerably fallen off both to nets and rods.

It is perhaps only repeating a truism to say that the reasons for the decline in British waters are not far to seek. The improved system of drainage, the inefficiency of passes, and the obstructions caused by weirs, are amongst the most conspicuous. Surface water is now carried off so quickly, that if fish could surmount the obstructions and ascend to the spawning grounds, these may run dry, or be flooded at the very time when salmonidæ breed, and in either case the eggs will be lost.

Manufactories are erected on the rivers, and discharge into them poisonous refuse which, if it does not actually kill every fish, renders the water unsuitable for the natural increase of the species. Manufactories have, perhaps, more to answer for than drainage or sewage; for whilst a river is dangerously polluted for miles below the works by chemical or mineral refuse, a stream on which no such works exist, and into which no great amount of sewage runs, still remains comparatively pure, and in occasional seasons produces a great number of young fish. Over-fishing is another cause of the decline of very many of our best rivers and lakes. Instances are not wanting where the fishery is not so valuable as it was formerly; and this, not because the water is less favourable to the growth of salmonidæ, but because it has been over-fished, and not stocked judiciously.

Again, when salmonidæ are allowed to breed naturally there is incalculable loss from several causes. The parent-fish are known to devour the ova as soon as it is deposited. Other fish hover about the beds, picking up every egg they can find. Dab-chicks, moor-hens, ducks, geese, and swans make sad havoc. The eggs are exposed to frost, sediment, flood, and drought, and unless the spawning-ground is under perfect control, so that the water can never run short, nor become swollen to any great extent, and so that any large fish which remain in the neighbourhood can be detected and removed, the results in the number of fish hatched are far from satisfactory, and bear no comparison with the results which are obtained by artificial breeding. Hence artificial propagation renders invaluable assistance in the case of all the varieties of salmonidæ; and were it not for artificial breeding, many waters would be all but depopulated of the particular species of the genus. This would be the case, not only with *Salmo salar*, but with the next, if not equal, in importance, *Salmo fario* or brook-trout.

So complete is the success, and so great are the advantages of artificial breeding, that numerous establishments for the sale of salmonidæ have been set up at a great outlay, and a large trade is carried on in all the varieties and in all stages. There are several such establishments in existence which turn out many millions of fish every year, and most owners or lessees of fisheries find it to their advantage to purchase from professional fish breeders in order to keep up their stock.

The necessity of artificial propagation increases as the taste for trout fishing becomes more popular. Anglers are far more numerous than formerly, and a large number of busy men insist on snatching a day or two a week during the season to devote to their favourite sport, and unless some real and permanent benefit were derived from such relaxation, we should not hear of such high prices as are given at the present time for trout fishing.

There can be no doubt that in England trout are bred for sport rather than for the table, although a dish of well-fed, pink-fleshed trout is not to be despised. Salmon proper is of enormous value as an article of food, and can always be obtained in the market at a price; but *S. fario* can seldom be procured at the fishmongers, and almost the only means of getting a dish of trout is through an angling friend.

The time will probably never arrive when we can buy trout as readily as we can salmon. For although trout could be hatched in sufficient numbers to supply the country, the waters devoted to their development are so small that they can never become plentiful enough to supply the market, at all events not until rivers and lakes which now contain only coarse fish can be stocked with them; and the impracticability of this is at once manifest.

Supposing it were possible to strip a whole river, from its source to its junction with the sea, of every pike and perch, the two most predaceous of our British freshwater fishes, there would then be the difficulty of obtaining the consent and co-operation of riparian owners in the stocking and preservation of trout; for there are many who prefer what is called "all-round fishing" in the autumn and winter, when almost all coarse fish are in good condition. There seems, then, no prospect of trout becoming plentiful enough in Great Britain to supply the market at such a price as would bring it within reach of any but the comparatively rich. Moreover, if *S. fario* were to become ever so numerous, anglers alone would monopolise it, and it would never find its way in any quantity to the market. The greater the number of trout raised, the larger the angling fraternity will become.

The country which abounds with fish will also abound with fishermen, and alas! the water which is well stocked with trout, is too soon found out by fish-eating birds and fish-stealing men and boys, who take by the foulest means, in and out of season, every fish, small or large, that they can lay hands upon. Salmon rivers and trout streams suffer alike from systematic poaching, and wholesale destruction is caused by taking fish in the breeding season. So long as poaching is carried on to the extent it now is, so long will there be a scarcity of salmonidæ in all but the best protected waters. Artificial breeding ensures the safety of the young fish during the most helpless part of its existence only, and no amount of care taken at this period is of any avail unless the water is protected when the fish grow older.

By protection is meant the stoppage of poaching, and the slaying of fish-eating birds, more particularly herons and king-fishers. Did the Poet Laureate, when he wrote these lines—

> "Nigh upon that hour,
> When the lone hern forgets his melancholy,
> Lets down his other leg, and, stretching, dreams
> Of goodly supper in the distant pool,"

dream of the terrible havoc which a few of these birds cause to our trout ponds and streams?

ON HATCHING.

This is, of course, the point from which all our stock of fish must commence, and everything depends on the quality of the eggs and their treatment at this first stage.

There is now no doubt as to the percentage of eggs which can be hatched artificially, if care is taken to procure ripe eggs from healthy fish.

The method generally adopted is called the "dry method," which is nothing more than using as little water as possible in the operation of taking the eggs. It has been so fully described in several works on pisciculture, that it is not necessary to repeat it here. Actual experience has proved that the best possible results in the fertilization of the ova are obtained by this method; and it is easily understood that the work of a fish-breeder is very much lessened when ninety per cent. (and occasionally more) of his eggs are impregnated and only ten per cent. remain to be picked out. To enumerate the different materials of which hatching troughs are constructed, and the various means of distributing the water through them, would carry one beyond the limit of an essay, and it may be sufficient to say that each particular breeder has his own favourite idea, and possibly each finds his own plan answer; some hatching troughs, however, occupy more room than others, and also require more water. In many cases much more water is used than is necessary; and it is not only waste, but dangerous to the egg and the young fry. A few general directions for the treatment of the ova may not be out of place here. The water should be of a temperature between 40° and 50°, and should be fairly pure. The eggs should be disturbed as little as possible by picking over until they have arrived at the stage when the eyes are distinctly visible, about the forty-second day. The formation of the fish is to be seen much earlier than this; but it is not advisable to move them, as a very slight concussion is fatal to them. As soon as the dark outline of the body and the eyes show distinctly, the eggs can be handled almost with impunity. They can be packed in damp moss, and sent long journeys if kept cool, and consequently the varieties of salmonidæ can be distributed over the greater part of the world. Eggs may also be exported, with a certain degree of success, if they are packed and placed on board ship within twelve or eighteen hours after being taken. This was the plan adopted in sending ova to New Zealand, and the writer offered the late Frank Buckland 10,000 freshly taken ova to send by the *Oberon* in 1873. The offer was, however, not accepted in time. Experiments were made in the writer's hatching-house, and it was found that the ova retained vitality for fifty-eight days in wooden boxes filled with fine shingle and sprinkled from a watering-pot every two or three days.

The loss of eggs from abroad may be attributed to careless packing, to the non-fulfilment of the first principle of fish culture—that of fecundating the ova, and to heating on the voyage. During the whole period of incubation, as it is sometimes called, all foreign substances, and dead ova, which turn white, must be carefully removed, otherwise fungus appears, and wholesale loss follows.

In from sixty to one hundred and twenty days, according to the temperature of the water, the young fish hatch, and from this time until they begin to feed there is very little loss; a small percentage will be deformed, and die, but the bulk being healthy, the umbilical sac is gradually absorbed until it entirely disappears, and the young fish are ready to feed.

ON REARING.

It has been found a comparatively easy matter to hatch and bring on to feeding point a million or more of salmonidæ; but to keep within bounds and to have at hand a tenth part of that number of yearling fish is a far more serious affair, and necessitates the construction of rearing places. An experienced American pisciculturist writes: "It is here that the greatest losses have occurred with most fish-breeders, and it seemed for a long time as if the wonderful art which had promised so much was to come to a stand-still at this gulf between the eggs and the yearling trout—a gulf which seemed as if it could not be bridged."* It is obvious that unless the fry can be reared, hatching by the million is but lost labour. If the young fish can be kept through the first summer, most of the dangers to which they are subject cease; they are less liable to be devoured by the larger fish; there are fewer losses from disease; and if sufficient space and good food are allowed them, and they are in other ways protected, as previously pointed out, they may safely be reckoned on as ultimately attaining their full growth.

It is simple waste of valuable fish-life to turn the young fry into waters which already contain large fish ; for they are incorrigible cannibals, and will live on each other as long as there is any great difference in their size, unless they can find plenty of natural food. If no more suitable place can be found, shallow parts of the stream should be selected, or little side streams, where no large fish can possibly get, should be made available; but one shudders at the loss of young fry when they are put into the main water; probably ninety-five per cent. would not cover it.

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* Livingston Stone's 'Domesticated Trout.'

Rearing boxes answer very well when only a few thousand fish are required to be reared for two or three months; but when as many as 50,000 or 60,000 yearlings are to be raised, nothing can equal small ponds. Small rills will rear them, but there must be a limit to one's grounds, and the fish will travel out of bounds.

Properly constructed ponds will retain the fish, and they are at hand when wanted. It is a mistake to suppose that trout will only flourish in a stream; it is not the current they require, but a tolerably constant change of water, which can be obtained in ponds. Ponds should be constructed so that they can be drawn off as often as necessary for the purpose of removing the fish ; and every patch of weed having been carefully looked over, there is little probability of any fish being left behind. The pond may even be left empty a day or two to make this a certainty. It has often happened that a dozen yearlings have been overlooked, and on the pond being fished the next season, these twelve fish have trebled and quadrupled their size, but at the expense of thousands of fry ; whilst, on the other hand, if the fry are turned into a pond entirely free from other fish, as many as eighty per cent. of yearlings have been found. One good reason why yearlings found is that the fry were starved before they were turned out, therefore they should not be kept too long in the hatching troughs, but put out as soon as they show the smallest inclination to feed; if they are kept back too long they will never recover.

If the rearing pond contains no natural food, it can be introduced, and one pond of a sequence should be retained for food alone. The fish can be fed artificially, i.e. on finely chopped meat, &c., but it occupies considerable time, and in the writer's opinion will not produce so good a fish in many respects as the natural food.

Streams which run through towns and villages will often provide, gratis, excellent food for large trout. There is frequently a quantity of offal, and other matter equally unobjectionable, passing through the drains, and at the exit is sure to be found a fish feeding on the scraps of animal and vegetable food which find their way into the river.

The ideal trout is, when placed on the table, pink-fleshed, and it is thought by many that the colour of the flesh is produced by the *Gammari* on which it has fed.

Still, trout do thrive on occasional meals of offal, and in some places, where the natural food is scarce, the fish are entirely fed on chopped meat.

Natural food is the freshwater shrimp (*Gammarus*), snails, larvæ of numberless water-flies, the perfect flies, and worms which are always to be found in earth ponds. Minnows and gudgeons make excellent food for large trout kept in confinement in stews; but it is by some considered objectionable to introduce them into ponds and streams, as they live on precisely the same food as the trout, and will probably consume much natural food which should go to the trout in the first instance.

The pond should be supplied with fresh water constantly passing through, and should be planted with weed, and this of the kinds known to be the best for harbouring the fish and encouraging the growth of insects. One of the best weeds for ponds is a variety of the *Potamogeton*, of which, through the kindness of a friend of the writer, an analysis is given.

ANALYSIS.

Organic matter	85 per cent.
Mineral matter	15 " "

The 85 per cent. of organic matter contains of nitrogen (the flesh-making element in the weed) 3 75 per cent.—very high, about the percentage of wheat. This proportion would be worth about £2 per ton of dried weed.

ANALYSIS OF ASH.

Lime	24·761 per cent.
Magnesia	4·522 " "
Potash	17·903 " "
Silica	12·022 " "
Carbonic acid	25·131 " "
Chlorine	4·425 " "
Sulphuric acid	5·346 " "
Phosphoric acid	3·683 " "
Soda	1·123 " "
Unconsumed carbon and loss	1·084 " "
Total	100· " "

A pond of half an acre has produced as many as 10,000 yearling fish, an ample number for most private fisheries.

Any one cultivating trout to a large extent must have many such ponds, in order that he may rear the different varieties; for some are hatched a month or two earlier than others, and having got the start, will assuredly keep it, not only to the hindrance of the later hatched fish, but most probably to their utter destruction. They begin to feed on each other almost as soon as they are able to feed at all, and it is therefore necessary to have separate ponds devoted to the different kinds. There is no one variety more cannibalistic than another; they are all willing and able to devour the smaller fry of other varieties. It may be called "ringing the changes" on each other, by which is meant that a *ferox* will devour a smaller *fario*, or a *fontinalis* a *ferox*, or a *fario* a *fontinalis*, &c.; the smallest or weakest going to the wall.

It is not asserted that fish of large size and others of half an ounce are not to be found in the same water; but it is certain that but very few of the smaller size will escape unless the water is of great extent.

Large trout do not roam far for their food, but take up a position suited to their particular views, and feed within a few feet of it; but woe betide the youngster who ventures too near this "Tom Tiddler's ground."

ON STOCKING.

There are thousands of acres of land of no value at all for arable or pasture, but which might, with little expense and judicious selection, be converted into suitable ponds for salmonidæ. The fall of the ground and the quantity of water may not allow of widening out a channel sufficiently broad to be called a stream; but at the same time there may be plenty of water to supply several ponds; and although pond fishing is never so fascinating as stream fishing, the water should be made the most of, and stocked with the kind of fish which it will nourish.

This can be ascertained by a simple experiment lasting over one year only, and if at the end of that time it is found that the water is not suited to salmonidæ, other fish might be introduced.

An estate commanding fishing, and more particularly trout-fishing, will fetch a higher price than one which does not possess this advantage, and ponds succeeding each other are always pretty objects in the grounds.

One sees in one's rambles rills of water running to waste through miles of ground, and they may possess every qualification necessary to produce good trout; but the owner does not know it, or is not interested sufficiently, or aware of the value of trout and trout fishing.

Many of these rills would make excellent rearing places for salmonidæ, and store fish could be taken from them every year to stock the larger river or lake on the same property. On the other hand there are many ponds and streams which, on account of the quantity of water or the nature of the soil, will not contain trout, and these may with advantage be stocked with the coarser kinds of fish. In the hope of introducing trout, owners of such waters have destroyed the fish which were already there, and have met with disappointment; for by the same rule which makes one piece of ground suitable for the cultivation of rhododendrons, and another unfit for them, it is unmistakably proved that salmonidæ will not thrive in all waters. It is, however, a curious fact that a pond, in a neighbourhood where trout have never been seen, will often produce very fine fish. The writer has a number of ponds in his holding which formerly contained almost every kind of freshwater fish except trout; but feeling convinced that trout would thrive in them, he had them cleared of the coarse fish, and stocked with salmonidæ, the experiment in almost every instance answering to his entire satisfaction.

One great advantage which ponds possess over streams is that the fish can be kept within bounds; and although, as a rule, trout do not multiply in them, yet the ponds can be run off in the spawning season, and a sufficient number of ova obtained to replenish the stock; or a neighbouring trout-breeder would probably be glad to return to the owner a proportion of young fish for the eggs so obtained; and some ponds are greatly benefited by being periodically drawn off, as the loose mud is washed away, thus helping to keep them tolerably clean. If ordinary care is exercised, no fish need be lost by running the water off, and the whole stock can be regulated as to size, so that there may be less loss from cannibalism. The lives of many small fish can be saved by the removal of a few monsters, and these may be put into another pond, or if one is not available, they should be destroyed, for a huge trout is as destructive amongst small fish as a pike.

Over-stocking, both in ponds and streams, is to be guarded against.

A piece of water will hold no more than a certain number of fish, and if more are introduced they will become thin and poor, and be not worth catching (to say nothing of eating).

It is impossible to lay down any rule for stocking, as everything depends on the quantity of food; one piece of water will hold a thousand large fish, and another of the same size will not grow a quarter that number. The kind of trout suitable for different waters must be ascertained by experiment, and at the outset some of each variety which are hatched about the same time should be introduced. It will soon be seen which kind is best adapted to the water, bearing in mind that the biggest water generally produces the largest fish. This is not, however, invariably the case, some small ponds bringing on fish very rapidly and to a great size. One pond of just an acre belonging to the writer produced in the second year fish of 3½ lbs., and in the third year the fish ran to 5¾ lbs. This is thought to be very exceptional, and as the pond was required for many thousands of yearlings, it was stripped of the large fish, so that there has since been no opportunity of testing its capacity in that way.

In concluding this head, it may be well to particularise the varieties of salmonidæ best suited to English waters. Leaving out *Salmo salar* and other migratory varieties, which must of necessity go to the sea, *S. fario* is the favourite. *S. levenensis* in its own beautiful loch is second to none; but it is a question whether its individuality will be preserved when removed to other waters. It is, however, a grand fish attaining to a large size. The only objection which can be urged against the *fontinalis* is that they travel, and are eventually lost to the original owner. But they are acclimatised in this country, and if confined in lakes or ponds which suit them, they are a most valuable acquisition: whether they are trout or char must be left for others to decide. *Ferox* require large and deep water, and have been reared in the writer's ponds up to 7 lb. weight, and caught with a fly. Grayling should, in the writer's opinion, be more freely introduced into our streams, as they are in the best condition after trout fishing is over, and rise well in November and December. They require most careful treatment until they are a year old, and the eggs are difficult to procure. There are several hybrids produced, and those from salmon and great lake trout produce a very fine alevin. The question of reproduction by some of the crosses of breeds is still open; but in some cases the ovaries have been seen in the female fish of two years old.

ON THE CARE OF FISHERIES.

It matters but little whether a pond or a stream will grow salmonidæ unless the water is protected in every way. In many instances, no sooner do the fish attain to half or three quarters of a pound, than they are at once fished at by any one who can get leave to do so, as well as by those who take French leave, and the fish do not get the chance to become larger.

Such injudicious slaughter can only result in the fish appearing to stop at a certain size ; and one is inclined to blame the water or the fish by concluding that they were not of a large breed originally, or that there are too many in the water. If the water is stocked too heavily, the number must be reduced. Artificial feeding would be a too tedious affair, and not altogether inexpensive, as according to Seth Green's calculation a thousand large trout will consume 5 lbs. of meat a day.

The introduction of "fresh blood" into fisheries has proved an immense advantage, but unless large fish are put into the water, one must wait four or five years before the benefit is seen.

In a stream in Berkshire the trout lost all their colour, became lank and spotless, a few years ago, but on the introduction of fresh blood, the improvement was most marked, not only as regards the size of the fish, but also their colour and quality.

Under the head of care of fisheries would come some sensible letters which have lately appeared in the *Field* written by one who is himself a keen fly-fisher, and one of the oldest trout-breeders in England ; for, if the writer is not mistaken, it was Mr. Francis Francis, who, with the late Frank Buckland and Stephen Ponder, did the work of the Thames Acclimatization Society some years ago. One who is at the same time an angler and a trout-breeder has the advantage over an angler alone, for the trout-breeder sees his water, and studies the habits of the fish and general condition of things at all seasons of the year. Thus, Mr. Francis's letters are doubly valuable.

Protection of a fishery is not complete without hiding-places, and these should be made so secure that no poacher can get at the fish. Many pieces of water are perfectly open to any poacher who knows how to handle a net, and can manage to evade the keeper.

It is therefore advisable to place solid obstructions in the way of any net, and these very obstructions will become the favourite haunts of the fish.

Weeds, instead of being ruthlessly cut out of whole reaches of a river, should be judiciously retained, as it is the weed which harbours *Gammari* and the larvæ of water-flies, &c. The wholesale destruction of weed is frequently the cause of the disappearance of the great fly of the season—the "May fly." It appears in the south of England about the end of May, and continues through the first half of June, to the evident delight of both fish and fishermen. The large fish are tempted to the surface by it, and then is the time to tell what stock of trout is in the water. The destruction of weed in a stream is as injurious to the fishing as the cutting of cover would be to shooting; neither trout nor pheasants will remain where there is no cover, and the best sport is generally obtained in a fairly weedy part of the stream, as the angler is more out of sight with a good patch of weed between him and the fish. If the weed is too luxuriant, judicious cutting should be exercised, but not at a time when the fishing season is at its height. Complaints from this cause are constantly heard, and on some rivers almost all fishing is spoilt on account of cut weeds floating down in the very best week of the season.

The writer of this essay is well aware that the subject of Propagation of Salmonidæ could be much more fully dealt with, but hopes that in his endeavour to be concise, he has not omitted the most important points in the culture of our most valuable freshwater fish.

THE PROPAGATION OF THE SALMONIDÆ.

"*THOROUGH.*"—[W. OLDHAM CHAMBERS, F.L.S., F.R.I.B.A.]

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THE

PROPAGATION OF SALMONIDÆ.

THE first consideration in the culture of salmonidæ is to provide an abundance of suitable pure water, and on this depends the secret of success.

Water generally.

Water may be divided into two classes—first, that for hatching; second, that for rearing and growing.

The water necessary for hatching must be of the purest nature possible, of one regular temperature, of about 45°, and containing a fair amount of oxygen, free from animalculæ, sediment, or other impurities; where practicable, water should be used from public resources, as its freedom from pollution may be depended upon. Next in order comes spring water; this can be raised by manual, steam, or other motive power.

Water for hatching.

Whichever is adopted, it is strongly recommended to have a large storage tank or cistern, in which to run the water before its service is required in the hatching-house. Water used direct from the public mains is often highly charged with oxygen, which soon disperses when exposed in bulk. Again, an ample store is most necessary in case of a burst pipe, short supply, or other misadventure, which frequently happens during the fish culturist's experience.

The second description of water is for the rearing of the

Water for rearing.

salmonidæ ; and, strange as it may appear, the very purity of the water, which is so essential during hatching, is death to the young fry, on account of its hardness and freedom from insectile life.

The water must, of course, be pure, but it is imperative that it should be charged with animal and vegetable life, for without this minute food the young fry will soon—far too soon—die by the thousand. If possible, collect the water from some little shady stream or rivulet that has for a distance purled along over stones and rocks, softening and oxygenating in its transit.

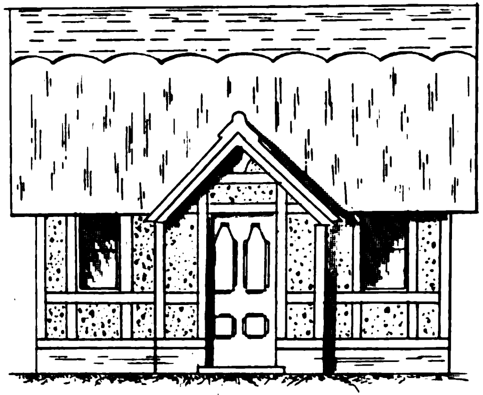
By all means, in selecting a stream, see that it never dries up ; always have *plenty* of water, never too little ; no man ever reared large fish with a scanty supply of water. Secure a fair, even and regular supply ; perfect the ponds against floods with as much security as against droughts ; this can easily be arranged by using a side branch or cutting, which will allow the overflood to run back into the main stream.

It will be remembered, in summary, that the water in both instances must be plentiful, that it must be pure, not liable to droughts or to floods, and not exposed to a super-abundance of sun ; it must not be liable to pollution from factories, sewage, sheep washings, or other like impurities. Water at all muddy for hatching is most detrimental, but for rearing young trout or salmon beneficial results will be found by occasionally stirring up the mud if the fry appear at all sickly.

Hatching-house.

The next consideration is the hatching-house, and the writer offers a suggestive sketch on other side for a building that would be found in every way adapted for the requirements of a small establishment. Although it is possible to hatch trout and salmon in an attic, cellar or common shed, still, any gentleman commencing the culture of salmonidæ

DESIGN FOR HATCHERY.



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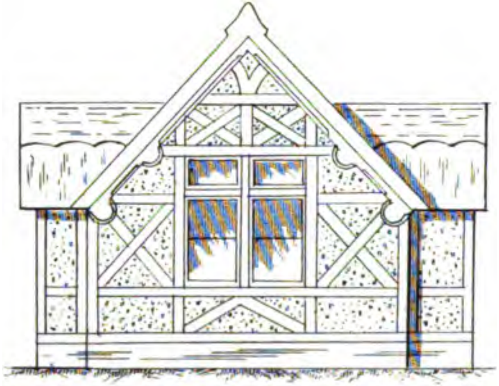
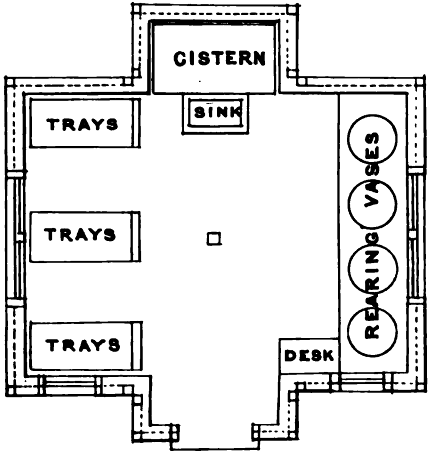
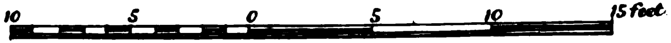


SIDE ELEVATION.



PLAN.

SCALE.



would naturally desire some guide or reference to work upon in the construction of a proper hatchery.

The roof should, if possible, be thatched, as it preserves the building from the extremes of either frost or heat. An ample supply of light must be given, as this is imperative to successful operations; during sunny days shades or blinds can always be supplied. The floor should be brick, with a trapped drain to carry off the waste water.

Fittings. A good paraffin stove will be found sufficient to preserve the house from severe frosts. Fit up in the windows good benches, and add a white enamelled iron sink, with tap for water supply over; this will be found most essential. The walls of the house can be built with boards to assist in retaining an even temperature. The store cistern must be placed *inside* the house; a receptacle can be provided under for food. A small desk will be found of great service in recording notes.

The building necessary for a large establishment to hatch, say, 300,000 eggs will naturally be far in excess of the sketch the writer has ventured to give, which is only intended for a small private enterprise.

Cistern. It is advised to place over the store cistern a small filter, through which to pass the water if it is found to be thick during the hatching season.

The system of filtration can either be charcoal broken up small, or by a series of flannel screens let into the sides of the box for the water to pass through, and capable of being removed easily for the purpose of being cleaned.

Hatching appliances. The appliances necessary in hatching are as follows: first, a suitable hatching apparatus, and upon this point much has been said and written. Every sportsman thinks his own particular dog or gun the best, so it is with fish breeding—every fish culturist considers the system he adopts is the best; different men prefer different methods, which may be briefly described as the *over*-flow and the *under*-flow systems. The former is that invented by M. Coste many years ago, namely, to place the eggs on gravel in slate or wooden trays stepped one above the other, and to allow the water to pass over the eggs from one tray to the other.

The other system is the underflow, which is to place the eggs in trays raised above the bottom of a box, allowing the water to enter at the bottom, pass through the trays and away at an overflow or waste.

It is not considered to be the purport of this essay to explain the various apparatus used in Europe and in America for hatching the eggs of salmonidæ or trout, but simply to present an arrangement that in the writer's opinion can be recommended on the grounds of simplicity, economy in construction and in the quantity of water used, and, above all, in cleanliness.

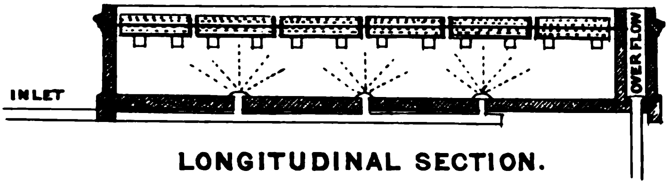
The writer strongly favours the underflow system, and has invented an apparatus, shown on other side, which has been found most successful in hatching operations. Any dirt or sediment is caught on the underside of the trays and does not come into contact with the eggs. By placing them in perforated zinc trays, they can easily be removed both before, during, or after hatching.

The apparatus is connected by a lead pipe with the cistern, the supply being regulated by a tap. The whole takes up very little room, and is easily stored away when not in use.

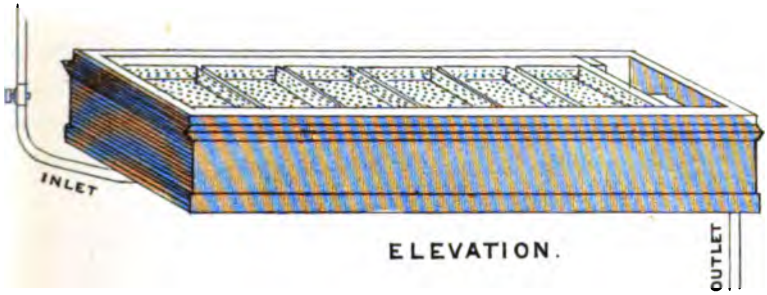
A box, say 5 feet long by 15 inches wide, is capable of hatching 30,000 salmonidæ.

When in use, the box is covered with a light frame, over which dark thick calico is stretched. It is most important that the apparatus should be covered; experience teaches

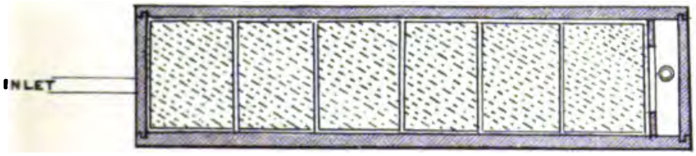
SALMONIDÆ HATCHER.



LONGITUDINAL SECTION.

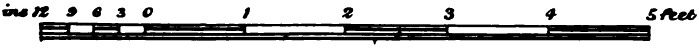


ELEVATION.



PLAN.

SCALE



fish culturists that the eggs hatch out better and stronger in the dark, and it assimilates more to natural hatching.

Looking over eggs.

During the period the eggs are in the trays they must be looked over at the least once a day, and great care should be exercised to pick out the dead eggs, which can easily be recognised by their white or opaque appearance.

The eggs must not be disturbed until the appearance of the eye of the fish; they are then known as "eyed ova," and in this stage can be packed on muslin placed between wet moss with a distribution of ice as required.

Eggs.

It is strongly recommended to small private fish culturists that they should purchase ova already eyed, instead of spawning it themselves, unless they have suitable facilities at hand. It has been intimated by an eminent fish culturist that with water at a temperature of 50°, the eggs will hatch out in 50 days, and for every degree, one way or the other, it will either advance or retard the fish 5 days.

With water at the above temperature the umbilical sac will last 30 days.

No particular attention is required during the alevin period, the rate of mortality is not great, and the dangers to guard against are comparatively few.

The newly hatched have a strong desire to congregate together up the corners of the hatching trays, and will escape by the smallest possible hole, in fact it is sometimes surprising to notice the power they have to wriggle through an almost invisible crevice in the trays.

Alevins.

The fish must be kept in the trays until about a week before they have lost their umbilical sac. The most trying and difficult stage now presents itself; if the fry are allowed to remain in the trays after the absorption of the sac, the very purity of the water, that up to the present time has been instrumental in hatching, will be the means of starving the fry. The writer has had years ago, with other fish culturists, the mortification of seeing his little family lying dead at the bottom of the trays without any perceptible cause.

If the fry are turned out in the open stream, the majority will in all probability fall a victim to the prey of larger fish, or succumb from inability to provide themselves with suitable food; the latter cause has killed thousands of good fish.

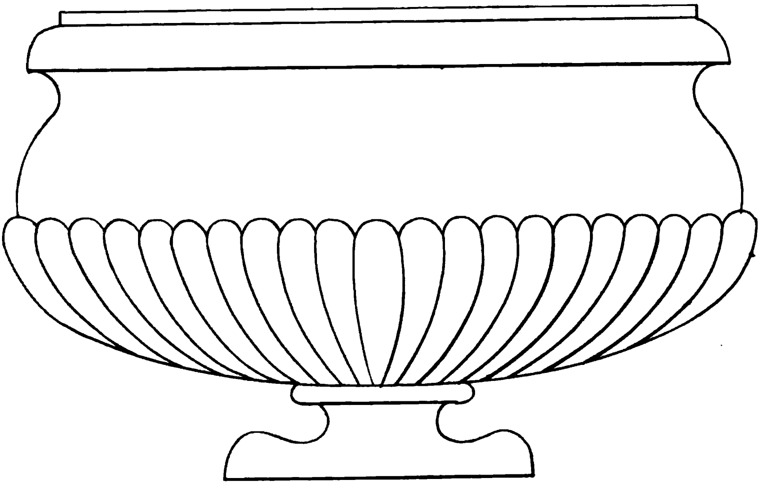
Feeding the fry.

It is therefore necessary that the young salmonidæ should—to use the term—be educated in the art of feeding before being turned adrift, and once they are able to feed themselves, half the difficulty ceases. With a view to facilitate this requirement, the writer invented an apparatus in which to rear the fish for the first two or three months. The apparatus takes the form of a circular vase made in terra-cotta; the water is introduced through a pipe placed about 1½ inches below the surface; the holes are pierced at an angle of 45°, consequently the water is forced round the interior, setting up a miniature stream. A tube 3 inches in diameter is placed in the centre to prevent a vortex, the bottom portion being made in perforated zinc; a standing waste is fixed in the centre of the tube, which can be drawn out without danger to the fish when the vase wants cleaning.

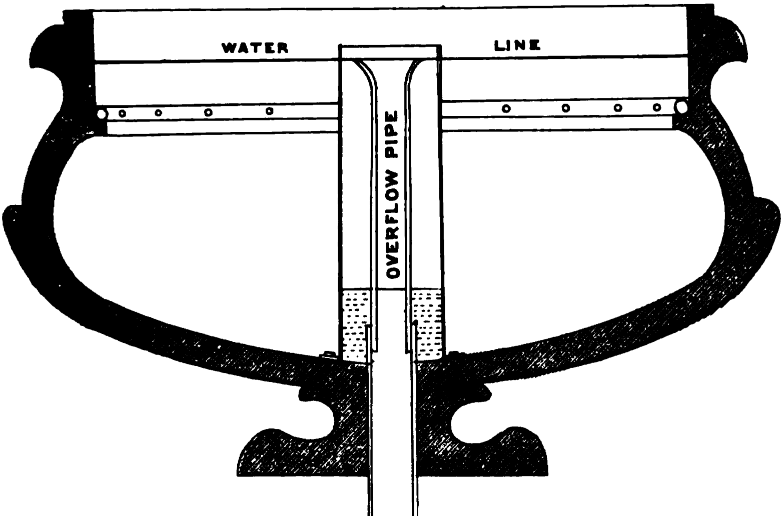
A drawing of the vase is shown on the other side. The writer has been enabled, since bringing out his invention, to save many and many a hatching of fry.

The next subject of importance is feeding the fry; this must be attended to with the greatest regularity. Commencing at first with only one or two meals a day, and gradually increasing it to three and four meals a day,

SALMONIDÆ REARING VASE.

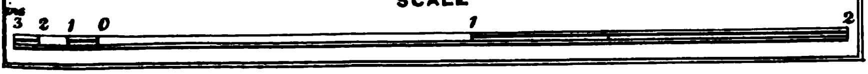


ELEVATION.



SECTION

SCALE



great care must be exercised only to give sufficient for the requirements of the one meal.

Salmonidæ are particularly fastidious in the way of diet; so long as the food is held in suspension in the water, so long will they consume it; but when once it has reached the bottom, they disdain to touch it. Food.

This is another point of advantage in relation to the rearing vase before alluded to. In consequence of the circular motion of the water the food is suspended for a considerable time, thus giving plenty of opportunity for the fry to feed.

During the early period of a young trout's life the most nutritious food upon which it can be fed is finely chopped raw liver. An admirable chopper for the purpose can be obtained from Messrs. Bradford in High Holborn.

Great precaution must be exercised to give fresh food every day; if the meat is at all tainted, fungoid growth is at once created.

There are, of course, other descriptions of food which perhaps some fish culturists would prefer to liver, such as curd, hard-boiled eggs and biscuit, but the writer prefers the chopped liver, and believes the fish thrive best thereon.

Constant feeding must not be neglected; big fish cannot be grown unless plenty of food is administered at regular intervals; nothing repays time, trouble, and expended capital sooner than attention in this particular.

After the fish are fairly established in the art of feeding, the period has arrived when they must be turned out into the open waters, and selecting a suitable habitation requires a vast amount of careful consideration and forethought, for which reference must be made to the early portion of this essay under the heading of water supply.

It is particularly recommended that the nursery pond Nursery pond.

should be of such dimensions that every portion of it is under entire control or management; for instance, the width at the upper surface should be about 6 feet and at the bottom 4 feet, and in length, say, 50 feet, with a depth of water at one end of 6 inches, and at the other 18 inches. It should be so constructed that the water can easily be run off by means of a sluice at one end into another nursery pond upon a lower level, provision being made next the sluice, by forming a "receiver," to catch the fish; this should be about 4 feet square and 1 foot deeper than the other portions of the pond.

The bottom of the nursery pond should have a lining of gravel 6 inches in depth; it is advised that a series of ponds be supplied in number according to the requirements of the establishment.

The fry ought frequently to be looked over to select the large fish, and to place them in ponds by themselves in accordance with their size and species.

Shelters.

A few aquatic plants should be provided in the ponds for the purpose of giving shade to the fish in sunny weather.

A few "hides" are very good in the shape of large stones, drain-pipes, &c., at the bottom of the ponds; whatever is placed should be capable of easy removal when necessary.

The fish must be as regularly fed and attended to as they were before being turned out into the open water: the description of food previously recommended must be continued. Avoid over-feeding and giving the food in large sizes, as it only sinks to the ground and fouls the water, the result being disease and death among the fry.

With ordinary care the fish will continue to thrive; they may be allowed to remain in the nursery ponds until the beginning of the following year, when they should be removed into larger ponds suitable for yearling fish.

Yearling ponds. The number of these ponds will also depend upon the size of the establishment. They must be constructed to allow of entire control in every portion, and not too large in area; about 40 feet by 20 feet is a convenient size, with about 6 inches of water at one end to 24 inches at the other; a gutter-way in the centre, about 2 feet wide and 1 foot deep, will be of service to conduct the fish to a "receiver," about 10 feet square, formed against the sluices into which the fish are caught when the water is drawn off.

The bottom of these ponds should have a few patches of gravel in places; some water-plants and drain-pipes to serve as "hides" for the fish will be of service in this respect; but nothing should be placed in the water that cannot easily be removed at a minute's notice.

Feeding yearling fish. Feeding must still be continued, but not so frequently as before described; twice a day will be all-sufficient, and the size of the food can be increased, but only in proportion to the size of the fish.

It will not be amiss to vary the food somewhat, and place in the water some freshwater shrimps, and also throw in occasionally a few garden worms, and in place of liver, give sheep's heart finely chopped.

If proper care has been exercised in this respect, the fish will now be about 6 inches to 8 inches in length; the trouble that has been expended upon them will begin to be repaid and appreciated. It is highly necessary that the fish should be carefully looked over periodically, and the large ones picked out and removed to another pond; it is by sorting into sizes that the percentage of loss through cannibalism is materially diminished.

Stock ponds. At the end of the second year the fish may be removed to larger ponds to be allowed to mature.

Their construction must be similar to the yearling ponds, only of increased dimensions. Always bear in mind that, whatever the size of the pond and to whatever purpose it is required, whether for large or small fish, it must be under complete control, as before described. When the water is drawn off, the fish must have a refuge or receiver, incapable of being drained, and in which they can congregate.

Feeding stock fish. Feeding must still be continued, although not so frequently; once a day will be ample; but always feed in the same place. The size of the food can now be increased; chopped cockles and mussels will be found of service, and coarse animal food may be given, such as the lungs, heart and pluck of sheep, provided the meat is fresh and reduced to a proper size.

With advantage, a few live minnows can be placed in the waters to serve as a change of diet.

It is well known that with salmonidæ a large amount of cannibalism prevails. One of the best measures to adopt in order to check this propensity is to feed the fish from their earliest infancy to the period when they are finally removed from the water.

This also reduces their wild nature, and will be the surest method to render them tame and domesticated in their confined condition, to which they can easily be accustomed by artificial resources.

Spawning. A few words may also be said on spawning. Prior to the fish passing up into the shallows in the autumn to spawn, it is advisable that some preparation should be made for them, such as cleaning out the streams, and adding gravel, if necessary, for the beds, and placing a few boards over the stream as a shelter or cover.

It will be observed before spawning the fish appear to have lost all inclination to feed; there will be no difficulty in catching them by means of a net. It is advisable to have two tubs filled with water, and to place the males in one tub and the females in another; the sexes can easily be distinguished, because upon gentle handling, if the fish are ripe, a little milt or a few ova are sure to be emitted.

The spawning pans must be ready and perfectly dry; gently take out of the water a female fish and grasp the head securely with the left hand, while your assistant keeps the tail in position; with the thumb and finger of the right hand gently press out the eggs, working towards the vent, allowing the eggs to fall into one of the pans. If there is any difficulty in passing them, allow the fish to go, and try another; any undue pressure will not only kill the fish, but render the eggs totally unfit for use.

The male fish must be now quickly taken out and operated upon in the same way, allowing the milt to run over the eggs in the pan; the two should then be mixed thoroughly together, and in about one minute a little water may be added, and again incorporate together: they must then be allowed to remain for not less than thirty minutes, the whole operation being performed as quickly as possible.

The milt of one male is quite sufficient to impregnate the eggs of several females.

Impregnation is caused by animalculæ, termed spermatozoa, in the milt of the male, which are mysteriously drawn towards the eggs.

The entrance of one or two through the micropyle or minute aperture of the eggs is sufficient for the purpose. When the eggs are first emitted they are somewhat adhesive, but half an hour after impregnation they are thoroughly free, and may be washed by a few changes of water; the eggs must then be placed perfectly clean in a can partly filled with water and be transferred to the hatching trays.

This is termed the dry system of spawning, and was the invention of M. Vrasski, a Russian gentleman. The old method was to place water in the pan before stripping the fish. As the eggs soon lose their absorbing power in the water, and the spermatozoa only live two minutes in water, it can be readily understood that the percentage of loss in the old plan was infinitely larger than in the new, which, if skilfully performed, only entails a loss of about 5 per cent.

In natural spawning not one egg in a thousand reaches maturity.

A fair average number of eggs in each female fish is 1000 to every pound weight.

After the first day, an unimpregnated egg may be readily distinguished from an impregnated one by a small annular disk on the top of the egg, which remains until it turns white.

THE SALMON DISEASE.

"*CLUTHA*."—[JOHN CLARK.]

THE SALMON DISEASE.

THE disease which during recent years has been so destructive to salmon, especially in the Tweed, has been known to occur occasionally in that river and elsewhere for many years, although its nature has only recently been investigated and come to be understood.

The testimony of old observers goes to show that large male fish have been known, from time to time towards the end of the spawning season, to be affected with what seemed to be fungoid growth, attacking chiefly the head and fins, but occasionally occurring in patches over the whole body.

The epidemic form which the disease has lately assumed is, however, of modern occurrence, and its aggravated outbreak in 1879–80, and its reappearance in virulent form in 1881–2, have attracted attention, and given rise to much variety of opinion as to its origin and the means of its prevention and cure.

It has been named *Saprolegnia ferax*, and is identical with a disease that occurs in flies. A fungoid plant, it takes root on the skin surface of the fish, is multiplied with incredible rapidity, covering in some instances the whole body of the fish within a few days of its first appearance, causing in aggravated cases intense pain, as is shown by the spasmodic motions of the affected fish, and ending in its death. Freshwater fish confined in tanks are also subject to the disease, but in general its progress on them is slow.

Artificial manures washed into the rivers have been by some supposed to favour the outbreak of the disease in salmon, but it is to be remarked that these are usually spread on the lands in spring, and must be dissipated long before autumn, when outbreaks of the disease usually begin.

Obstructions in rivers preventing the ascent of gravid fish, and causing the congregation of large numbers in pools, have been pointed to as a producing cause of the disease; but this in turn must also be set aside, when we remember that in the Tay, where no obstructions exist, a serious outbreak of the disease arose in 1881–2.

The disease has also been attributed to pollution of rivers from the discharge of refuse from dyeworks and manufactories on the river bank, and from town sewage. These causes doubtless lower the vitality of fish, and possibly give rise to a condition more or less favourable to the growth of the disease; but this also must be set aside as the producing cause, the origin of which must be sought elsewhere, for we know that fish occasionally sicken and die from such pollution when it is great, and yet do not develop the disease, and it appears in tanks where no such explanation of its origin is possible.

None of these causes being sufficient to account for the occurrence of the disease in its malignant shape, we must look for its explanation elsewhere.

For some years I have been studying, as opportunity permitted, the manifestations of the disease, and have experimented with fish under various conditions with a view to ascertain how it was communicated and the course it ran.

In the autumn of 1881 three fresh-run salmon were netted in a small river, four miles from the sea, not polluted by sewage. They were placed in an adjoining shallow pond, where a good run of pure water passed through it, and in a few days these fish got fungussed. No other fish were in the pond at the time, but some powans (fresh-water herring) developed the disease in the same pond a year or so before.

In the spring of 1882, two grilse kelts, in good health, and about to descend the river to the sea, were captured and placed in the same pond; they were confined under the same conditions as the fresh-run salmon, but a full fortnight elapsed without any disease breaking out, and the fish were then turned into the river. In February of the present year (1883) I made various experiments with smaller fish. Capturing a pond fish about four inches long (I did not identify the kind), which was in poor condition, I wiped the mucous covering of its skin from one of its sides, leaving the other untouched, and put the fish into a glass globe filled with water, into which I had introduced a little fungus from a diseased salmon. In twenty-four hours the disease appeared well diffused over the wiped side of the fish; in forty-eight hours it had extended over the other side, and upon its head, death ensuing.

I next placed a number of minnows in the infected water, but none of them were affected by the disease; one minnow I kept in it until the water was becoming offensive, but still the creature remained untouched. I changed the water, put some fresh fungus into it, also some which had developed on addled salmon ova, in my possession, and placed three minnows, one being from the first set referred to, in the globe. The minnows began to pick off the fungus from the ova, until they removed and apparently ate it all. Next day the first minnow alone was slightly fungussed upon the back, fin and tail, but the disease did not progress. On the third day I gave the little fish a salt bath, which removed the disease, leaving a portion of the back, fin and tail eaten away.

I recently tried a couple of healthy dace: from one I removed, with a soft toothbrush, the mucus from one shoulder. In thirty-six hours I observed the commencement of fungoid growth, and two days afterwards the shoulder had a thick coating of fungus. No other parts of the fish were attacked, and its companion remained perfectly clean and healthy.

These, and other observations to which I shall allude, lead me to attribute the disease to two distinct and separate causes: one, the peculiar susceptibility to the disease of the fresh-run salmon, arising from the condition of its skin-surface upon entering fresh water; the other, the liability of fish which have become weakened, or have lost their mucous covering through fighting or any other cause, to attacks of the disease.

The primary cause or origin of the disease I do not profess to know, any more than we can explain the originating cause of any of the zymotic diseases with which we are familiar. We know that smallpox and fever germs exist, but where they come from and how generated is a mystery: when they do exist, however, be the form ever so modified, it is only necessary to bring them to conditions favourable to their growth and increase, and they will extend and become epidemic; and when, in turn, they are perceived to occur, the remedy consists in separation of the infected from the healthy, and the removal of conditions favourable to the spread of the disease.

Now it has been remarked that the salmon disease seldom attacks native trout or other habitual denizens of the river, and that it occurs in its virulent form among comparatively fresh-run fish. It seems probable, therefore, that there is some peculiar proneness or susceptibility to the disease in the fresh-run salmon when it enters fresh water. When a salmon, direct from the sea, is examined, it will be found to be bright and firm, its scales clean, and the body comparatively free from mucus ; this condition of the skin is characteristic of the fish in salt water, and for some time after entering fresh water. When the salmon has been some weeks in the river, its hue changes and the whole surface of the fish becomes covered with slime ; in some cases, especially among males, it is so thick as to hide the scales. Sea-trout undergo the same transformation, and both they and salmon resemble river-trout in the condition of the skin, which, as is well known, are always more or less covered with mucus, and defile the hands and the baskets of fishers.

Doubtless the exudation of mucus serves some important purpose in freshwater fish, and probably it is designed to protect them from skin diseases, to which they may be specially exposed in rivers. It is observed that parr are covered with the freshwater slime while they remain in the river, similar to native trout.

The salmon disease is known to exist in three forms : one, the virulent epidemic with which we have lately grown familiar ; another, the sporadic form of the ailment which is often observed in individual fish prior to spawning ; and third, the normal form, occurring chiefly in old male fish at the close of the spawning season. From the first and second forms of the disease recovery seldom occurs ; but from the third, recovery is occasional.

The fungus, besides requiring a suitable nidus, requires bright light for its development, and this fact explains the occasional recovery from the third form of the disease; spawned fish retiring to the deeper pools, into which bright light does not penetrate, and the ailment slowly disappears.

I lately examined a kelt sea-trout, caught in the Tweed, which had well-nigh recovered from the disease; the fungus was still present near the root of the tail, but the mucous flow had overspread the body, and was encroaching upon the tail; the marks of the disease were visible in the form of light patches.

These observations lead up to what appears to be a reasonable explanation of the virulent form of the disease.

Fish coming into fresh water from the sea, and before acquiring the mucous covering which they would afterwards receive, come in contact with diseased fish existing in the river, or with spores shed from diseased fish, and the fungus, finding a suitable nidus upon their unprotected skin, is rapidly developed in the shallows to which these fish resort.

The experiment with the fresh-run salmon transferred to the shallow pond, to which reference has been made, supports this theory; but it receives striking confirmation from a number of the observed circumstances attending recent epidemics.

The epidemic in the River Eden in 1878 occurred in the spring of that year, and attacked with special violence the fresh-running fish. It is recorded, that out of 1271 dead and dying fish taken from the river, 1000 were fresh-run.

The Tweed epidemic of 1879–80 occurred, as the years indicate, in the middle of winter. The run of fish in this river is peculiar; the first-spawning fish begin to run in October, and seem to complete their work towards the end of December, when fresh shoals of fish, locally known as the grey school, consisting both of salmon and grilse, begin to run and appear on the fords in immense numbers at the beginning of the year; the grilse, being the later arrivals, continuing into March.

A severe frost had set in early in winter, and continued into the new year. The grey-school run of fish entering the river were prevented from going directly to the redds or spawning fords, but were detained under the ice in the deeper waters, mixing freely with the spawned fish of the earlier run. When the ice broke up, they appeared in very large numbers upon the redds; a sudden snap of frost again occurred, which drove the fish back from the spawning shallows into the pools, and there they were observed, in the course of a few days, to be dying in immense numbers of the disease. The fish had caught the contagion on their first entrance, probably from the descending kelts confined in the pools; it developed upon them when on the shallow fords, and they died as described.

The Tweed epidemic, 1881–2, again occurred among the fresh-run grey-school of salmon. A number of cases were observed to exist among the fish of the earlier run, which appeared to affect the new grey-school run of fish immediately upon their appearance in December, and before the new year they were dying in thousands.

We thus see that the disease finds its greatest development among fresh-running fish proceeding to the shallows.

From the experiments made with acclimatised fish protected by their mucous coating, it is seen that the disease can hardly be communicated. In the case of fish recovering from the disease, the mucous coating is observed to have overspread the parts from which the disease has disappeared, and to be encroaching upon the parts still affected.

The salmon disease has reappeared this last year on the Tweed, although not to so great an extent as in the previous years; and it will, I fear, reappear with each recurring migration of fresh-run fish, until the river is purged of its disease, so that fish may have time to acquire the protecting mucous coating before coming in contact with contagion.

The remedy seems to be a thorough netting of rivers, such as the Tweed, before the early migration begins; all diseased fish found should be destroyed, and those captured clean should, before being returned to the river, be bathed in salt water, to destroy any germs that may have found a footing upon them. The river bailiffs might, with advantage, be employed at the work. Should the epidemic again show itself, an effort to stamp it out, as one would an outbreak of foot-and-mouth disease, should be made; and at the close of the spawning season, when weakly fish are occasionally attacked, they should be sought out and destroyed.

In this way, and in no other, can this malignant ailment be coped with.

I would further suggest that rod-fishing, without any close time, should be allowed upon the Tweed,—legitimate fly and phantom fishing only. All the fish that would thus be captured would be nothing compared with the numbers that are poached or die of disease. It would serve as a protection against poaching, and would place on the river skilful and observing anglers, who, while pursuing the sport, would help to extirpate the disease, either by themselves capturing the fish, or drawing attention to them, in order that they might be removed. By such means as I have indicated, I feel sure that, the disease which has produced so much havoc among fish, destroying an important source of wealth, may be kept in check, if not eradicated, and our rivers restored to their formerly healthy state.

SALMON DISEASE:

ITS CAUSE AND PREVENTION.

"*SALUS POPULI SUPREMA LEX.*"—[W. ANDERSON SMITH.]

SALMON DISEASE:

ITS CAUSE AND PREVENTION.

OF late years the spread of the salmon disease—the fungoid or algoid growth, *Saprolegnia ferax*—has been so rapid, and its effects so disastrous, that great attention has been directed thereto. From the alarm caused by this dangerous parasitic growth, many have supposed it to be a wholly novel and unaccountable visitation, and the consequence has been that the assault made upon the enemy has partaken of the empiric unscientific character that generally accompanies all endeavours to cope with an unknown quantity.

The natural history of the disease and its mode of attack have been so thoroughly explained elsewhere, that we do not propose to cover this well-trodden ground. The simpler individual modes of curing diseased fish are also of a character such as we do not consider of any great consequence, and we therefore proceed at once to deal with the broad general principles by which the progress of the disease is explicable.

Like most apparently sudden onslaughts of disease, whether it be Asiatic cholera among mankind, or pleuro-pneumonia among cattle, or any other scourge, the ground for the most part has been prepared for its reception; and we hold that the salmon disease is no exception to the rule, but that at least a quarter of a century of preparation has paved the way for its successful *début* in force.

It is now more than sixty years since the disease was known, and it is more than a dozen years since we made its acquaintance first in a small but thickly-stocked river in the north of Scotland, where the fungus made its appearance one extremely dry summer, when the fish were crowded in the pools of the river. As the fish were for the most part naturally vigorous, the fungus did not make great progress, and only a small proportion were badly sickened, through the presence of the fungus in a large white patch behind the head. This continued for some time increasingly, until a heavy rainfall enabled them to leave the river pools, either for the freshwater lochs, whence the stream emanated, or for the sea.

Since that time, until a few years ago, we did not again meet with its recurrence; but our experience of late years clearly indicates that similar natural or artificial conditions have produced, in the first instance, most of the salmon epidemics of our various rivers.

We would consequently divide the causes of the disease into—

First. Insufficient oxygenation; and

Second. Low vitality, partly produced by the above.

I. INSUFFICIENT OXYGENATION.

We will deal with the causes that lead to insufficient oxygenation first, and these may be considered under the following heads:—

I. Want of a sufficient regular body of fresh water in rivers.

II. Overcrowding of the spawning fish in particular limited breeding grounds.

III. Excess of organic matter, such as sewage, devouring the natural oxygen of the rivers.

IV. Excess of physical impurities.

V. Excess of chemical impurities.

I. It would appear as if our rivers were as deep and as full as ever they were, and it might be reasonably asked how, with our present annual rainfall, compared with previous cycles of years, we can talk of a deficiency of fresh water. Yet we do not hesitate to say that in most of our great rivers even the regular water supply is deficient, compared to what it was a quarter of a century ago. This result has arisen from the enormous increase in drainage wherever agriculture or sheep farming is carried on, so that whereas formerly our rainfall slowly and steadily filtered through natural outlets into the great water arteries, these are now filled to overflowing for a day or two, to be left at a much lower level for weeks to follow. At these times of low water the fish in the rivers congregate unduly in the deeper pools, where they soon exhaust the life of the water beyond the point at which the slowly-running stream can replace it. In this predicament the sea-trout run a better chance than the nobler fish, as, from their smaller size, they can penetrate into portions of the watercourse inaccessible to the salmon, and consequently they frequently escape the disease when the larger fish succumb to it. Although extremely vigorous and of great vitality in the water, the sea-trout does not endure the treatment that the salmon will—rarely living in a salmon box—so that we must credit their comparative immunity from disease to their smaller size, and consequent capacity to utilize waters quite inaccessible to the salmon, and to ascend the small, pure streamlets that join the main rivers.

II. Overcrowding in limited breeding-grounds is the natural consequence of a sudden influx of spawning fish of the same season crowding, as far as possible, towards the upper reaches, and out of the tainted lower courses. Many stretches of river formerly utilized by the larger fish have been deserted, owing to the state of the waters, and these all go to swell the company in the other spawning-grounds. The heavy spates caused by excessive drainage have also ruined many gravel banks formerly frequented, and, for the most part, the fish in our rivers may be calculated to have had their available spawning-grounds considerably decreased in extent.

III. Excess of organic matter. Our great rivers have hitherto been, in many cases, looked upon as partly drains, partly sewers, by the rising towns and villages upon their banks; and when we calculate the amount of organic matter of the most repulsive kind thrown recklessly into such rivers as the Thames, the Clyde, the Severn, the Tweed, or even the Tay, the wonder is, not that the fish stock should be subject to epidemics, but that any fish life, especially of anadromous fishes, should exist therein at all. Almost all our cities of importance are not only built upon our rivers, but near the mouths thereof, so that all salmon that may succeed in passing up, do so half sickened and greatly weakened by a prolonged race through diluted—and frequently but partially diluted—sewage.

We are told that such sewage rapidly becomes oxygenated, and consequently purified by the water; but this simply means that it uses up the dissolved air in the water, and therefore leaves it less suited for even the transitory existence of fishes than if it had remained a nauseous but isolated nuisance. Where towns are situated within the tidal influence, as London, Newcastle, Glasgow, and many others, the regular ebb and flow of the tide merely aggravates the nuisance by periodically carrying the congregated impurities back again, instead of sweeping them away. We have no doubt, therefore, that the passage through such polluted estuaries and lower river-courses is a terrible ordeal for the salmon tribe, although the organic matter may ultimately vastly enrich these same estuaries in their seaward range, and improve them as haunts of the coarser marine fishes.

IV. The excess of physical impurities acts very differently from the foregoing, but in some respects with equally disastrous results; and these are the more regrettable, as they do not seem to be so difficult to grapple with. The quantity of earthy matter carried down by freshets from surface-drained land is frequently very great, and adds another injurious ingredient at the very time that the fish are seeking to take advantage of the rush of water and are leaving the quieter pools. Where a river is sluggish and full of earthy materials, these are so light and minute as to be non-objectionable, but a hurriedly-borne mass of matter is largely composed of particles of an irritating character. If the sawdust from a saw-mill, or the chaff from a flour-mill, are permitted to add, however little, to these suspended particles, the irritation is no longer discomfort, but frequently death.

From the whole of a river, through surface drainage and reckless manufacturing, the quantity of physical impurities now discharged into most of our greater rivers must add considerably to the injurious effect of the water upon the salmon tribe.

V. The excess of chemical impurities is, however, in some of our more important rivers and streams, in every way more deleterious than any other pollutions. Not only do they injure the water by reducing its purity and absorbing or throwing free the enclosed air, but they are themselves directly and immediately of a poisonous character, and tend to act in a large river still more injuriously than even their greater excess will act in a small one.

Thus, while the chemical impurities in the Tweed may be sufficient to produce a very low tone of health in the contained fish, they do not prevent these fish endeavouring to reach the higher breeding-grounds. But those of the River Leven, flowing from Loch Lomond to Dumbarton, are of so pronounced a character, that the bulk of the fish are forced to wait until closed mills enable them to run through to Loch Lomond with a rush. Should they attempt to run at other times, they are occasionally to be caught in dozens as they come gasping and poisoned to the surface of the stream. In a case of this sort, the death rate does not at all indicate the health rate of a river, any more than it does of a town; and, indeed, it would be far better were the fish wholly poisoned in quantities, than that they should be altogether reduced in health and vigour, without the public attention being called to the injury until it has progressed so far that it is almost too late to check it. The proprietors of mills upon the Esk have shown, by the value of their recovered waste products, the extent of the injury previously done to the waters by these same waste liquors; and it is no use for any one to declare that a mass of impure water is not injurious to a river because it is not directly poisonous. It, *at least*, occupies so much space in the river, and by so much reduces its capacity as a fish stream. As an evidence of how much impurity there is in waters little supposed to be deleterious, we may instance the fact that an important industry has arisen in France from the manufacture of potash from the washings of sheep fleeces, and this being so, the great woollen manufactories of the south of Scotland ought to be obliged equally to utilize this waste that goes to pollute the abused waters of the Teviot and Tweed. But if this simple process throws free so much impurity, the other manufactories—chemical dye-works, print-works, tanneries, &c.—total an amount of obnoxious material that must have reduced the fish life of the rivers so visited to the low condition prevalent among humanity dwelling in the slums of London, Liverpool, or Glasgow; so that the general health of the salmon frequenting such streams, and bred in them, has been brought into a fit condition for being attacked by the first virulent epidemic.

This brings us to what we consider the second great cause of the disease, viz.:—

II. Low Vitality.

This is not only produced by the deficient oxygenation above described, but by—

a. Injudicious over-preservation of kelts and weakly fish.

b. Injudicious culture preventing the "survival of the fittest."

a. In the preservation of our salmon rivers we have two distinct objects in view—the capture, for the season, of a reasonable quantity of large wholesome fish, and the deposition of a sufficiency of spawn to maintain the river at its level of fish population. To this has been added the prevention of the destruction of spawned fish (or kelts), as they may return clean next year, either to be a source of valuable food, or again prove fruitful. The result in many rivers is that these lean gluttons, unwilling to face the poisoned lower waters until the last moment, being well protected and encouraged to pursue their evil ways where they are, remain for a lengthened period, and devour the spawn and young of their neighbours, as well as their weaker brethren. Knowing the danger of the lower waters, they gradually increase in numbers in the upper pools, until they reduce the vitality of all around them, as well as their own, through the special *over-population of limited areas of water*. We have no doubt whatever that a large proportion of kelts should be killed off in the larger rivers, or, if so desired, they might be netted and kept in enclosed areas of water for a time. At present we are satisfied that their over-preservation in many rivers is a direct source of injury to the fishings, as well as a cause of reduced vitality from keeping these kelts to recuperate in foul waters, and to continue the species at the cost of younger or more vigorous fish.

b. Injudicious culture.—It has been too frequently the custom to treat all salmon alike, and to be satisfied with what comes to the net in the spawning season. Too great care cannot be exercised in choosing vigorous clean fish, of medium size, for breeding purposes; and they should be chosen both from the late and early migrations, so as not to overthrong the river at one season of the year.

It may be reasonably held that the fry, once incubated, are subject to the ordinary vicissitudes of fish life, and come under the ordinary rules that procure the "survival of the fittest." But we ourselves are scarcely prepared to accept this, and are inclined to believe that all weakly, backward fish should be removed from the ponds; and even that ova, long of incubating at a proper temperature, should be held as showing a deficiency of vitality. The river Awe, the outlet of an extensive freshwater system, used to furnish "shiploads" of fish for export to the Spanish market during Lent, while now, from the continued capture of early fish, it is not worth the while of the lessees to wet their nets before April. The fish are consequently at present produced from the later migrations only, and no more "shiploads" of fish are heard of from the district.

Having come to the conclusion that the salmon, our largest and finest freshwater fish, has been assaulted on all sides until, through deficient oxygenation and gradually reduced vitality, it has been unable to throw off the incubus of this virulent fungus, we may also add our belief that these latter years have been particularly depressing to animal life, even in the waters, owing to the deficiency of light and warmth. We know to a certainty that fish are readily affected by these, as instance the herring, even at sea, where it keeps to the bottom during depressing weather. At the same time we never recollect such seasons for the luxurious propagation of all species of fungi, which seem to flourish best under a muggy atmosphere. We are thus provided with all the conditions needful for such an epidemic, and the spores of this fungus have not failed to take advantage of the position.

Prevention by—

I. Purification of rivers.
II. Less tenderness towards kelts.
III. Rigorous removal of weakly fry.

I. It seems almost unnecessary to dilate in this connection upon the necessity for the purification of rivers wherein our stock of salmon abide for a time and spawn; and this subject has been so long before the public, that much of novelty can scarcely be imported into the discussion.

We would divide the problem into several parts, corresponding to the degree of pollution and the extent of work demanded.

a. Those large rivers thoroughly polluted by great cities and accumulations of factories.

b. Those minor rivers polluted to a certain extent by numerous towns and isolated manufactories.

c. Those small streams similarly polluted.

d. Aëration of streams.

e. Settling of sediment.

a. Under this heading we would place such rivers as the Thames and the Clyde, long wholly given up to manufactories, and for which many panaceas have been suggested, hitherto without result.

Until, by means of earth closets, sewage reclamation, and other great schemes, these waters are kept free from the bulk of the cities' impurities, we suggest that the only plan for fish culturists is to insist upon an independent pure entrance to the upper waters from the estuary, so as to avoid the more hopelessly polluted section of the river. Whether this is worth doing may be open to question, but we see no other way out of the difficulty without stupendous efforts such as the cities are not yet stimulated or forced to take.

b. In the case of these minor rivers, or rivers with minor pollutions, we think the public have every right to demand a main drainage scheme by which the water, incapable of purification, may be carried seaward conterminous with the river. All water drawn from the river should be purified to the utmost extent that our present knowledge can arrive at, with reasonable regard to cost, the remaining unpurifiable portion to be run into the main drain. The difference between *a* and *b* would be that, whereas in one case we should have a small pure stream alongside the great main sewer, in the other we should have a sewer running alongside the main stream. No doubt such an arrangement would mean considerable expenditure, but we do not concede the right of individuals to pollute our air and waters for their own aggrandisement, without an honest, even if costly, effort to prevent the injury. The rivers by right may be said to belong to the nation, and it is the duty of the nation to see that, so far as possible, they are wisely employed. The manufacturing interest has long been very tenderly dealt with, and, considering its vast importance to the community, this is but just. In most instances when planted alongside the streams and rivers they pollute, they were received with open arms by the neighbouring inhabitants, to whom they brought labour and increased value of produce. But the steady increase of pollution has surpassed all bounds in many quarters, and the polluters themselves are seriously incommoded by their fellow pollutionists. Therefore an equalised pressure upon all manufacturing establishments contributing to the fouling of a stream, as well as upon all towns and villages adding their sewage thereto, ought to be welcomed by such interests as a whole, even when the individual establishments would severally have looked upon enforced purification as merely a drop in the bucket on their parts. We have thus no doubt that, while on principle the nation has a right to insist upon towns and villages keeping their sewage from polluting their streams, in practice there would be no real difficulty in securing such a result. At present the position assumed by all parties is that the best means of obtaining results have not yet been decided upon, that vast strides are being made in science, and we must all wait a little until a simpler solution of the problem is obtained.

This is a simple fallacy. We have waited long enough to have obtained valuable results from the crudest operations had they been carried out, and on the same principle we might all die of starvation waiting for a better mode of cookery, or a superior class of food. Common sense and common usage bid us do the best with the means at our disposal; and the enormous capital spent of recent years in education under the School Boards shows how ready the nation is to insist upon expenditure when it is considered needful. If the result of this education is to show the paramount importance of fresh air and water, we may hope for less difficulty in furthering the legislation necessary for the alteration of our rivers from open sewers full of sickly fish into streams of life-giving water.

c. These small streams similarly polluted.

As an instance of the comparatively enormous injury done to the fishing interests by fouling a small stream, we may take the Leven from Loch Lomond. This river is not more than ten miles long, but by it the great extent of Loch Lomond, and its many tributary streams, must be stocked with breeding fish of the migratory species. Upon its banks have congregated the great wealth-producing Turkey-red dyeing works of Scotland, and at its mouth lies the thriving shipbuilding and engineering town of Dumbarton. The tidal influence, for the most part, renders Dumbarton innoxious, but the various dye-works keep the river poisonous six days of the week. Not only do they poison the water for the fish, but for each other, so that they have to arrange to divide the pure-water days among them, or else those lower down would in vain seek for that purity on which the superiority of their dye greatly depends. A large sewer, to carry off the unpurified water after using, could be made from the neighbourhood of

Loch Lomond to the tidal river, a distance of but 10 miles, at small comparative cost to a wealthy community, and with infinite advantage to the district, throwing open throughout the week the greatest extent of inland fresh water in the kingdom.

d. Aëration of streams.

We would strongly recommend that when the more manageable, and even the larger, rivers are comparatively polluted, where water is withdrawn for temporary purposes, the conservators of the river should insist upon its being returned in a great shower, or broken fall of several feet. This, when practised generally, would do much to prevent that fatal "deadening" of the water through the exhaustion of the contained air, and at the same time help to counteract the injurious effect of sewage water. While the number of great weirs upon the English rivers are a sore trial to the fish culturists, it must be some small consolation to think that, where pollution is added, they so far assist in diminishing its evil results through the additional aëration of the water thus produced.

e. Settling of sediment.

In the case of large sheep-drainage areas, bringing down an excess of sediment, tanks or pits, of a size commensurate with the drainage area, might be sunk at the exits into the river in which the heavier sediment might settle, and permit the purified water to flow over. Still, except as another straw on the overladen camel, we do not consider surface-drainage operations as of the most serious importance on many rivers.

II. Less tenderness towards kelts.

We have already expressed our belief that over-preservation of spawned fish is a distinct evil, and we hold that a large proportion of them hulk about the pools of the rivers, and do more injury than even their certain return and capture as clean fish could ever repay.

A wise discretion in this direction would, we believe, be attended with distinct advantages.

III. Rigorous removal of weakly fry.

The removal of all weakly fry, where artificial breeding is resorted to, and greater care in the selection of the most vigorous fish, ought, we think, to be attended to. It seems to us that artificial breeding, having long emerged from the ruder stage of the art, ought to be exercised with as much care as the breeding of other stock. If the most vigorous progeny are produced from a "young cock and an old hen," will somewhat similar physiological conditions not rule with respect to fish? And at any rate it stands to reason to expect that greater care in the choice of breeders will be rewarded. There are many clean rivers still untouched by the dreaded fungus, and whose fish are full of native vitality; but to transfer their spawn to the poisoned Tweed would be of no real advantage, for they would be still more susceptible, in all likelihood, to the injurious influences of the river than if they had been gradually accustomed to a lower vital action. The improving of the water must, in all cases, precede the endeavour to increase the vigour of the inhabitants. At the same time, we believe the fish stock should be largely crossed, and would suggest for this, not the energetic fish of lively rivers like the Findhorn, but the heavy lethargic fish from peaty rivers, accustomed to a comparatively low display of vitality.

We are aware that many will shrug their shoulders hopelessly when the assault on rivers pollution is suggested as the principal remedy for the prevention of salmon disease, and ask what there is to be done. In full belief that the fish of our filthy rivers "want air," we reply that if a family cannot live in a small room with a foul atmosphere, half a family may be able to exist in it. So that if we cannot manage to clean our great sewers, we must be satisfied with a lesser number of healthy fish. This stands to reason, and although those who declare our rivers are not overcrowded are perfectly right under natural conditions, they overlook the fact that the conditions, not being natural, the fish are really overcrowded until the natural conditions are returned to. This year the fish in the River Tay are fine, vigorous, healthy fish, as hitherto captured, a great proportion of the weakly fish having been killed off, leaving more room in a river fuller than usual, from the wet winter.

Indeed, we are disposed to think that before long nature will solve the problem for us, and the salmon be superseded by the hardier sea-trout, able, as this fine fish is, to penetrate into regions of fresh water unattainable by the salmon. But this will merely be a step further, and unless the pollution problem is tackled boldly, our river fisheries will be wholly represented by eels, able to exist with a minimum of aëration.

THE
CULTIVATION OF FRESHWATER FISH
OTHER THAN
SALMONIDÆ.

"*STILL WATERS RUN DEEP.*"—[R. B. MARSTON.]

THE
CULTIVATION OF FRESHWATER FISH.

ONE of the most remarkable things in connection with the ancient art of angling is the amazing increase of its disciples which has taken place within the last few years. And although this increase has been large among salmon, trout, and grayling anglers, it has been far greater among those who, not having the means or opportunity to angle for the salmonidæ, give their attention to our other freshwater fish, such as pike, perch, roach, bream, carp, chub, &c. A few years ago the angling clubs of London and Sheffield could be counted by the dozen, now they number many hundreds with many thousands of members. A few years ago angling clubs of the kind referred to here hardly existed in the provinces—to-day we find them springing up on all sides and in all parts of the country. But, while anglers have been increasing in this wonderful manner, the fish have been most certainly decreasing. The cry from the clubs is: How can we get fish?

Something must be done for these thousands upon thousands of anglers, for without fish their recreation is gone, and that they should be encouraged will be admitted by every one who gives the matter a moment's reflection. The larger portion of these coarse-fish anglers are working men and youths, mechanics, artizans, miners, toilers in our mills and factories in the great centres of industry,—men to whom every inducement should be held out to attract them into fresh air and scenes in their spare time. How, then, is the decrease in those fish, in the capture of which they take such delight, to be stopped? and how can the thousands of miles of water which might yield them sport be replenished? To answer these questions will be the object of this essay.

That these questions need answering at all proves that, in this country at least, very little has been done in the direction of cultivation of coarse fish, though, as a matter of fact, in the case of most of them it presents far less difficulty and expense than is attendant on the breeding of the salmonidæ.

The first thing to be recognised is that, consequent on the great difference in the modes of spawning of the salmonidæ and coarse fish, a widely different method must be adopted. Salmon, trout, and grayling eggs are non-adhesive, and each egg can thus be manipulated separately they take many months to hatch out. The eggs of the coarse fish are adhesive, making their manipulation extremely difficult—so much so, that while ninety-five per cent. of salmon and trout eggs can be hatched out, those who have attempted to treat coarse fish eggs in the same way have rarely succeeded in rearing even five per cent. The eggs of the coarse fish hatch out in a very short time, a week or ten days being the average time required. If, then, we had to look to what is called artificial breeding to enable us to increase our coarse fish, the prospect would not be an encouraging one.

But, fortunately perhaps, artificial breeding is not necessary in the case of coarse fish; all we need do is to give nature a certain amount of aid, and she will do the rest for us.

In the Berlin Fisheries Exhibition, 1880, there was

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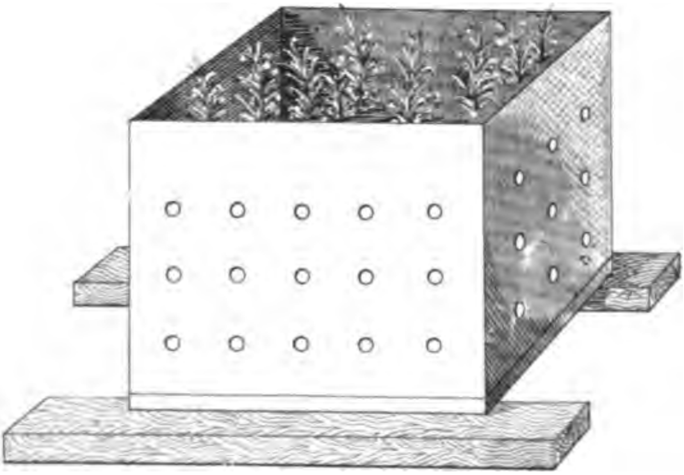

exhibited in the Swedish department the model of a box, known as Lund's hatching box, for some kinds of coarse fish. This box was described for the first time in England by Mr. R. B. Marston, Editor of the *Fishing Gazette*, in a Paper he read before a meeting of London anglers at the Society of Arts Room last year.*

It is simply an ordinary box—its size depending on the number of fish it is to hold—with holes drilled in the sides to permit of a free current of water through it. The interior is lined with fir branches, and in Sweden, where it has been in use for over a century, it is used thus: Shortly before their spawning time a few pairs of male and female fish (perch are principally cultivated in this way) are placed in the box, which has previously been anchored in a pond, or lake, or stream. The water is not allowed to flow over the top of the box, which is kept some inches above the water level. The box either rests on the ground, or, by means of wooden floats, is kept at a proper level. The parent fish deposit their ova on the fir branches, and they are then taken out; in a few days the young fish hatch out and are found in millions amongst the branches. They can then be either liberated in the lake or other water they are in, or transported to some other water it may be desired to stock, or the fecundated ova can be transported in the same way. Here, then, we have a most simple and inexpensive way of obtaining any quantity of that most valuable fish, the perch. The box ensures that the incredibly vast number of ova deposited by a few fish are protected from the numberless enemies which would attack them in the open, even supposing that the parent fish had been able to find a suitable and undisturbed place in which to deposit them. It is simply aiding nature, for the whole operation goes on exactly as in the ordinary way. Sun, air, wind and waves can exert their beneficial influences, while the ravages of storm and flood are provided against. M. Lundeberg, the Swedish Inspector of Fisheries, says that although used chiefly for perch, they can (with slight modifications of the material on which the spawn is to be deposited) be equally well used for roach, bream, and some other fish. The successful use of this box in Sweden shows clearly that if properly tried in this country many of our coarse fish can be cultivated to any extent. But there are some kinds of coarse fish which require different treatment. To confine pike in a box of this kind would not be difficult, but it would necessitate the use of such a large one, and the growth of such a comparatively large quantity of water weeds, as might not often be practicable. To obtain a stock of pike, probably the best plan would be to place in a small pond, or in an enclosed part of a larger one, a dozen or so of male and two or three dozen female fish, as nearly alike in size as possible. The place selected should be chiefly shallow, well overgrown with water-plants, and with a deep place for the fish to retire to when disturbed. As soon as the spawning is over, the parent fish should be removed, and in a few days the young pike will hatch out. If they are in a small pond, they will require feeding with freshwater shrimps, worms, &c.; they grow very rapidly if well fed, and in two or three months' time can be netted out and sent to any part of the country. In the case of their being wanted to stock a large water, by removing the fine wire netting forming the enclosure above referred to, they will be able to spread out and find their own living along its shores.

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* It is also described in a paper read by Mr. Marston on the same subject at one of the Conferences of the International Fisheries Exhibition (Ed.).

To cultivate carp the best plan is to place twenty or thirty pairs of parent fish in a pond from which *all other* fish have been removed. As an instance of what wonderful results can be obtained in carp culture, may be mentioned the fact that last summer, Herr Max v. d. Borne, the well-known German pisciculturist, placed some dozens of pairs of parent fish in a pond on his estate, and in the autumn, when the water was drawn off, *over ninety thousand young carp were found.* Another instance of the possibilities of coarse-fish culture is afforded by the fact, that whereas a few years ago there was not a single carp proper in America, now they exist there in millions—the progeny of a very few parent fish imported from Germany by the United States Fish Commission. In the face of results like these, what need is there to fear that the coarse fish will disappear? Their abundant increase is *only* a question of judicious farming.

The chub is a fish which it would probably be difficult to breed in a Lund-box; in the first place, it is an extremely shy fish; and, secondly, it, like the dace, barbel, and gudgeon, prefers a sandy and stony bed in a stream on which to deposit its ova. But given a small stream of good water, and a bed suitable for these fish can be most easily formed. It is then only a question of protecting them efficiently from water-fowl and other destroying and disturbing influences, and confining the fish placed in the streamlet as much as possible to one kind. A few dozen parent fish protected in this way will produce hundreds of thousands of fry, and directly they have done so they should be removed, or they will commence to destroy it. The fry will require feeding on finely-minced offal, as is done in the case of trout. Supposing, for instance, such a society as the National Fish Culture Association possessed a fish farm which included one or two streams, what difficulty would there be in their adapting the streams to the not very varied requirements of such coarse fish as could not well be bred in the Lund-box? Any one who has seen what Mr. Silk has accomplished for Lord Exeter at Burleigh Park will know that a very small stream of water, with a flow of hardly more than a gallon per minute, can be utilised in forming a series of most excellent breeding and feeding ponds.

But in addition to the Lund-box and the breeding-ponds, there are yet other methods by which coarse fish may be increased, and they are specially useful in those waters where there are no good natural spawning-grounds, or where, when they exist, they cannot, for some reason or other, be made use of. The water traffic on many rivers prevents the fish getting that undisturbed rest they so much require at this time. In such a river breeding-hurdles can often be used with great advantage. Ordinary hurdles, with branches interlaced, are sunk in such places as offer the best chance of quiet and protection for the fish while spawning. These hurdles are in use in many parts of France and Sweden; they are more suited to increasing the native stock of a river than for general breeding purposes like Lund's box.

Our English freshwater fish are of such various and valuable kinds, that the question of introducing foreign fish is one which should be most carefully considered. But there is one candidate for naturalization—if indeed it is not already naturalized—which, provided it is placed in suitable waters, appears to be eminently likely to provide sport for coarse-fish anglers, and sport of a kind which they could only get otherwise from the salmonidæ. This fish is the black bass of the North American Continent, a fish esteemed by American anglers even above the trout. It is a fish of prey, like the perch, and should, of course, not be placed in trout or grayling streams; indeed, it thrives best in ponds and lakes. In sport and food qualities it is undoubtedly superior to any of our coarse fish. The successful importations of it made by the Marquis of Exeter and some other gentlemen prove conclusively that it will do well in this country; indeed it is doubtful if there exists a more hardy fish, or one which can be more easily cultivated. This will be made evident by a short description of the wonderful manner in which the black bass provides for the safety of its young—in striking contrast to the habits of nearly all other fish in this respect. The black bass spawns in May or June, according as the season is early or late. The parent fish go in pairs, and select some place where the bed of the water they inhabit rises nearly to the surface, where the sun's warmth may reach the eggs. If they can find no convenient shallow, they will heap up stones on the bottom and make one. Before the eggs are deposited, the parent fish most carefully clean the space they have selected by brushing it with their fins, and by carrying away from it with their mouths all *débris*, such as twigs, stones, &c. These cleaned spaces are readily distinguished by their contrast to the dark weed-covered ground around them, and many of them may be seen in the lake (White Water) in Burleigh Park, in which the Marquis of Exeter placed some hundreds of black bass a few years ago.

American observers of the black bass have placed things on these cleaned spaces, and have seen them carried away and deposited outside by the black bass. The nest prepared, the female deposits her eggs in it, and the male impregnates them. Then both fish keep jealous guard over them for some ten days, when the young hatch out. Every intruder is fiercely driven away; nor does their care cease here, for, keeping their young together, as a hen does her chickens, they convoy them to some shallow place amongst reeds and weeds, where they will be safest from the attacks of other fish. This care is continued for some days, until the fry are strong enough to scatter and look after themselves. It will thus be seen that a few parent fish will speedily stock a water without aid of any kind. But inasmuch as the cost of bringing over these fish from America has hitherto been at the rate of about ten shillings each, it will be evident that the cost is too great to permit of many fish being used for stocking purposes. To place a very limited number of fish in a large sheet of water might result in their becoming too much scattered to get together again in the breeding season, therefore it is advisable to place them in very small ponds, or else to enclose with wire netting a portion of a large sheet of water, and keep them there until they have spawned. A great recommendation in the eyes of anglers should be the fact that the black bass rises freely to the fly, and will also take baits of every description, and, when hooked, affords superlative sport. It is as free from bones as the trout, the flesh is firm, white, crisp, and delicious, with curd between the flakes. At the same time it would be most unwise to advocate its general and indiscriminate introduction into our waters. Let it be confined to some of those numberless ponds and lakes which now afford no sport to the angler.

A question intimately connected with the cultivation of fish is that of the best and cheapest way of feeding them. On the Continent fish culturists are beginning to realise the fact that the cultivation of their natural food—freshwater crustacea, insects, frogs, flies, worms, larvæ, &c.—offers the simplest and best solution of the question ; in fact, the cultivation of the food of fish should keep pace with the cultivation of the fish themselves.

THE

PROPAGATION OF FRESHWATER FISH,

EXCLUDING

SALMONIDÆ.

“*THOROUGH.*”—[W. OLDHAM CHAMBERS, F.L.S., F.R.I.B.A.]

THE

PROPAGATION OF FRESHWATER FISH.

THE measures by which our food fishes can best be multiplied have more or less from the earliest periods of time received the consideration of mankind.

Introduction.

The first attempts at breeding, rearing and cultivating fish were made by the Chinese, and can be traced back to periods of the greatest antiquity; it was a national source of wealth, and proved of great value in the supply of daily food and in relieving distress in time of famine.

Early history.

Several instances are mentioned in the Bible as far back as 2000 years B.C.

The Romans spent large sums of money in the culture of fish and construction of ponds and lakes, notably that *bon vivant* Lucullus, history informing us that he bored through the sides of a mountain to introduce sea-water into his fish-ponds.

Roman works.

During the middle ages pisciculture had many patrons, and the monks contributed in no small degree to its success, as it presented them with the means of food during their religious feasts and ordinances.

Ponds of middle ages.

In many parts of the country very fine examples of ponds or stews are visible, showing great engineering skill in their construction.

No trace of fish culture in modern periods.

Although means have been adopted for the artificial propagation of salmonidæ during comparatively modern periods, we are devoid of any reliable data as to practical endeavours in this country to cultivate any of our national coarse fish for the purpose of restocking our depleted rivers and food-producing acres.

The science of fish culture is now no longer a question of experiment based on scientific results, but one of national economy in the production of a cheap and wholesome aliment for our densely populated cities and manufacturing towns, and in this respect we are bound to consider the science.

Harmony of nature.

The laws effecting the harmony of nature are governed not only in view of the countless dangers fish in their embryo and alevin condition have to encounter before being able to contribute to the reproduction of species, but also to the innumerable difficulties attending the fecundation of the eggs in their natural condition.

Impregnation.

The direct contact of the milt with the ova is of course necessary to create the development of the germ. Eggs, therefore, failing to receive this impregnation soon decompose in ordinary or natural spawning, and a very high percentage of loss may from the above cause be anticipated.

Enemies.

After the eggs are hatched, the enemies that prey upon the young are very numerous. The natural desire to feed on each other, the attacks of fish-eating birds, water insects, crustaceans, &c., all tend to retard reproduction.

Fish have, therefore, to contend against all these calamities before being able to take their place in the repopulation of our waters.

The purport of this essay is to show how we can assist nature in the restocking of our waters by the adoption of certain simple measures tending to that end. **Assist nature in stocking.**

The species of our national coarse fishes best adapted for cultivation must be well considered, and the writer would venture to suggest, *inter alia*, the following, not only in giving sport to the angler, but in furnishing food to the people, namely, pike, perch, carp, roach, tench, bream, dace, &c. **Species to cultivate.**

These may be divided into carnivorous and herbivorous feeders, and an undue increase of the former will, in the ordinary law of nature, represent a corresponding decrease in the latter.

To meet this, we find a greater fecundity is given to herbivorous fish than to their carnivorous *confrères;* while the latter in their turn prevent a too great increase over the former ; so is the balance of nature preserved.

In considering the question of the restocking of rivers, this feature must not be lost sight of, that as food fishes the carnivorous species are infinitely superior to the herbivorous : great care must be exercised in selecting a fair proportion of each species, in order to retain an equitable balance. **Food fishes.**

The spawning of British coarse fishes varies from the salmonidæ in this respect, that whereas the latter shed their ova in the winter free, or non-adhesive, on gravelly bottoms of streams, the latter yield their ova in the spring or summer months, and select stones, trunks of trees, weeds, rushes, &c., upon which to attach the eggs, which are adhesive in character. **Spawning.**

They delight in moderately still waters, and select shallows for the better incubation of their eggs ; also on account of the minute insectile life found therein, for the young fish to feed upon when hatched.

Propagation.

In considering the question of propagation, it has been shown in the former part of this essay that the natural enemies of our fishes are multitudinous, not only in their ovum and embryo stages, but also in their alevin condition, and measures should therefore be adopted, as far as possible, to guard against the difficulties that are known to exist in carrying out a scheme for the cultivation of our coarse fishes.

Artificial fecundation.

Experiments have been made in the artificial fecundation of the eggs of coarse fishes, and apparatus have been constructed for the hatching of adhesive ova upon wooden frames over which linen has been stretched ; also upon sheets of glass placed in boxes with water allowed to pass through, until the eggs are hatched, when the young fish are removed, as may be desired ; but these experiments are not to be relied upon in leading to results of a satisfactory nature, for unless a uniform and natural temperature of soft water is obtained, considerable disappointment will follow.

The hurdle hatcher.

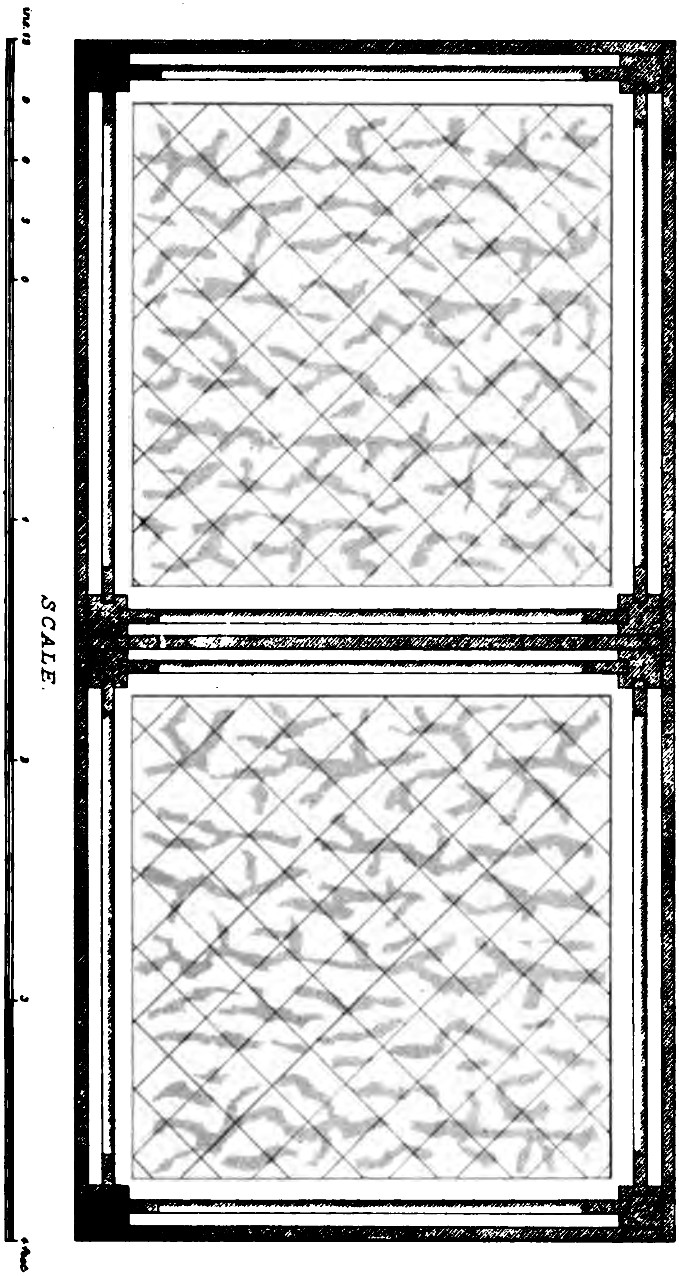
Reference must be made to a German invention, known as the wooden " hurdle," through which branches of the fir tree are intertwined, and the framework is then sunk in suitable places for the fish to spawn upon.

Hatching box.

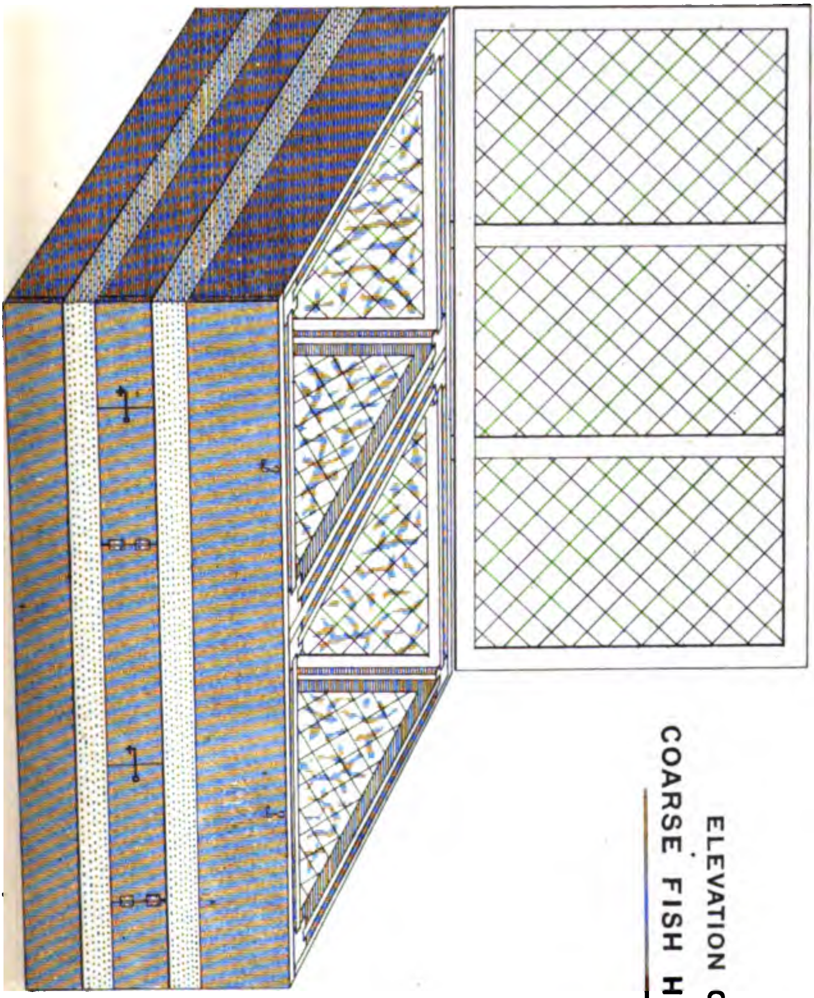
Special reference must be made to an apparatus which forms a leading feature in this essay ; it is so designed that fish may be placed in it to spawn, after which the ova can be either left to hatch in the natural course, or removed to distant waters.

Such an apparatus the writer of this essay has had the honour to invent, a drawing of which is given on the other side. By reference thereto it will be seen that the structure is oblong in form, the length being about five feet, the width two feet six inches, and the depth two feet.

Form of the apparatus.

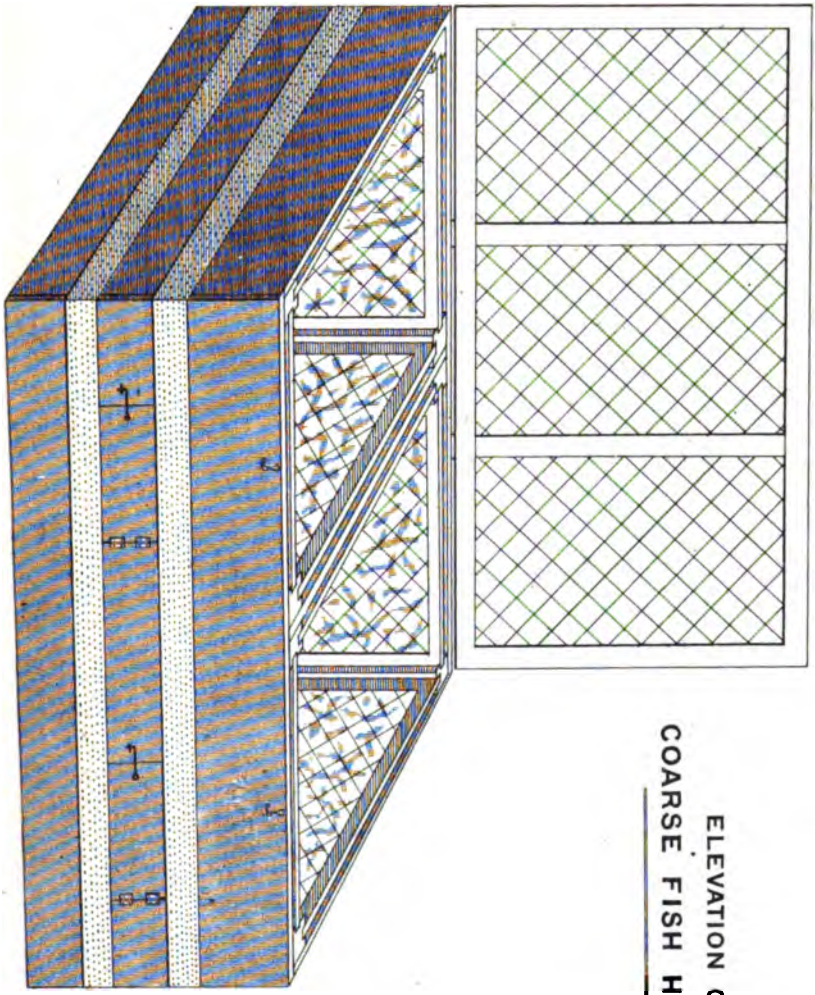


PLAN OF
COARSE FISH HATCHER
(Looking down)



ELEVATION OF COARSE FISH HATCHER

Plate II.



ELEVATION OF
COARSE FISH HATCHER

The outer framework has strips of perforated zinc inserted, three inches in width, for the free passage of the water.

In the centre of the box is a division for the purpose of separating the species if desired.

Round the interior of the box, including the bottom, are provided light frames, upon which is stretched galvanized netting of 1½ inches mesh; into this netting are intertwined young fir branches, and a lid formed with galvanized-wire netting closes the whole of the apparatus, which is then ready for use.

How to use the apparatus.

Previous to spawning, the box is secured on the margin of a lake, small tributary, or other approved position; a few pairs of carefully selected ripe fish are then placed in the box, and in due course the spawn is deposited on the fir branches; if it is intended to stock the water in which the box is situated, it is simply retained *in situ* until the young fish are hatched; a small door in the side is then removed, and in due course the fish find their way into the waters; but supposing the intention is to transfer the eggs to a distant part of the country, the frames are then drawn out, with the fir branches and deposited spawn, and placed in a carrier filled with water, and forwarded to their ultimate destination. The frames are taken out, and sunk in the new waters until the eggs are hatched.

The whole of the woodwork used in the construction is charred, to prevent fungoid growth.

The Lund hatcher.

In Sweden for more than a century there has been an apparatus in partial use, known as the "Lund" hatching-box.

The writer claims for himself the originality of design in the above-described box, both in the construction of the invention, and also for the purposes to which the same can be applied with so much simplicity.

This essay upon the cultivation of fish can hardly be considered complete without a few words on the formation of artificial ponds.

Artificial ponds.

In designing and superintending the construction of fish ponds, the writer has always upheld the principle that the most convenient and profitable form is to have a series—namely, nursery, yearling, and stock ponds.

The whole should be designed so as to enable the water to be easily drawn off by means of sluices, thus placing under entire control the whole of the ponds, as may be required from time to time.

It is highly desirable, where space will admit, to have more than one nursery pond, in order to separate the herbivorous from the carnivorous fishes, and thus regulate the number in each species in stocking waters.

Nursery ponds.

The nursery pond should be shallow; three feet wide at the bottom, six feet at the top, and about fifty feet in length.

Gravel should be spread along the bottom to six inches in depth, weeds and drain-pipes may be dispersed about for shelter; the depth of water should vary from four inches at one end to ten inches at the other. A very slight current of water will be sufficient to retain life; a few bushes planted round the edges will be of service for shade.

When the sluice is lowered and the water drawn off, provision must be made to catch the fish in a "receiver," five feet long and one foot deep, incapable of being drained; protection must be given by perforated zinc placed at an angle of 45° to prevent the fish passing through in the pond at a lower level.

Yearling ponds.

The yearling pond must be much larger, and constructed in a similar way, with a depth of water from six inches to two feet: gravel the bottom in places, and provide suitable water-plants and "hides" for the fish.

A ditch three feet wide and one foot deep should be formed in the centre leading to the "receiver," as before described; the ditch will assist in conducting the fish to the receiver when the water is drained off at the sluice.

It is necessary, in addition to the "hides" named, that stumps of trees should be fixed in the banks at places, thus affording suitable shady spots for the young fish in the summer months.

Bushes must also be planted round the banks with overhanging branches.

Stock ponds.

The stock ponds should be considerably larger than the last described, and constructed similar to the yearling pond; they must be provided with shallows one foot in depth, as they afford means for the growth of insects.

The average depth of water in the ponds should be about three feet; there is no benefit in deep ponds; holes can be sunk six feet deep for the larger fish.

Little bye-streams round the sides are of great advantage, and they should be supplied with water-plants, upon which the fish may spawn.

Management of ponds.

It will much facilitate the growth of the fish, more especially in the cultivation of the carp, if the ponds can be laid dry periodically during the spring and summer months, and planted with oats and rye-grass.

No pond should be used longer than three years for aqua-culture; the bottom becomes foul and rank from the alluvial deposits; these should be raked off and removed, and the surface ploughed up. The oftener a pond is laid dry and exposed, the faster the fish will grow.

Advantage of the series system.

A great advantage will be gained by having a set of three ponds for stock or fattening purposes, and alternate them, as before described, with agri-culture.

It is difficult to lay down a hard-and-fast rule as to the number of fish to be placed in a given area of water.

As it is with pastures so it is with waters, some are rich and productive in the extreme in supplying nourishing food, whereas in other instances the opposite we find to be the case.

Dangers of overcrowding.

Broadly speaking, every care must be exercised by a frequent examination of the condition of the fishes, to avoid overcrowding; it will be far better to err on the side of over-caution in this respect, than heedlessly to stock the waters with a superabundance of fish, that would only result in a supply of lean, starved, and ill-formed fish, fit neither for the rod, nor for the table.

Food.

Suitable food should be given at regular intervals, avoiding large quantities at a time, which would only sink to the bottom and soon decompose, causing fungoid growth to the inhabitants of the waters.

The best food for our coarse fishes generally is large and small lobworms, brewers' grains, meal, oilcake, &c., cut to sizes according to the age of the fish.

The warmer the weather, the fleeter the water to distribute the food, and the colder the weather, the deeper must be the feeding. Very young fish only feed on minute insects, which may be encouraged by placing in the water newly made hay or old grass.

THE HERRING FISHERY.

"*PROGRESS.*"—[R. HOGARTH.]

THE HERRING FISHERY.

IN the early history of our nation the North Britons were fonder of the chase, or an occasional raid by night on salmon with torch and spear, than looking after the treasures of the deep.

Little is known of herring except that the Dutch visited our coasts annually for the purpose of fishing them, returning often with good harvests. It is difficult to understand why Britain did not cultivate such an important industry, allowing the Dutch to have it all to themselves, unless it was the many wars she was engaged in and the continual local feuds that kept her hands full, for it would appear that this branch of fishing was very little followed after till the middle of the seventeenth century, and even then it remained for a long time unproductive, for many reasons, of which I will mention a few: first, the fishers were nearly all small crofters, who, as they derived their subsistence chiefly from their crofts, did not require to prosecute the fishing to any extent. If they earned as much as would pay their rents and get a few necessaries that their land did not supply, they were content; and as they lived a very frugal life, their wants were but few.

Causes of the neglect of fisheries.

Unproductive even in 17th century.

Reasons.

Another reason was that their materials were not good. The boats that were used for fishing did not suit the

Materials defective.

Boats (their build, &c.).

purpose well, being nearly half as broad as they were long, and open from bow to stern. There was no place of shelter in them, nor any way of cooking their food. Oars were always used, but the fishermen always carried a large blanket with them, which served both as a covering to keep them warm and a sail when the wind was fair. These boats were round-sterned—from fourteen to sixteen feet keel and about seven feet beam. It was not possible to go any distance to look for herrings in boats of this description. They were known by the name of "nabbies."

Nets and their manufacture.

The nets were also very indifferent, being all home-made. The women spun the twine, and it was very coarse, twice as heavy as that used at the present time. The fishers themselves made the nets.

Crew.

The term "barrel."

There were generally four men in each boat, and each boat carried a train or fleet of nets consisting of four barrels, one for each man, the name "barrel" arising from the habit of carrying their nets in barrels when going from one fishing station to another. The barrel or net was not made in one length; it consisted of thirty "deepings," each deeping being twelve yards long and fifty meshes deep, the size of the mesh being rather more than an inch, or what we term thirty-four rows per yard. I will now proceed to make some general statements, confining myself to the west and north coasts of Scotland.

Opinions of writers regarding migratory habits of herrings. These opinions contradicted.

The method of fishing is nearly alike as regards herrings on all the British coasts, except "trawling," which I refer to afterwards. Buffon and other writers were of opinion that the herring was migratory, that our coasts were wholly supplied from the Arctic regions, and that herrings visited our coasts in spring and left in early winter. The spawning banks off Ballantrae and others around our coasts have proved the fallacy of these opinions. In regard to these statements, I remember hearing an old legend told, how that herrings were only to be found on the east coast of Scotland; so a silver herring was made and towed after a vessel or boat round Cape Wrath, and the whole shoal followed and filled all the west coast.

An old legend.

I do not doubt that we get a supply of herrings from the oceans around, but I think we depend chiefly on the herrings bred in our own waters. Men of experience seeing herrings in any of our markets can generally tell where they are caught.

Herrings from the oceans around.

Distinctive marks in herrings of separate localities.

Herrings fished at different places have their own peculiar appearance, such as Loch Nevis, large; Loch Hourn (6 or 8 miles distant), small; Scalpa, large; Loch Broom, small; Hebrides, all large; Loch Fyne, generally large; and Firth of Clyde, generally small.

Places quoted.

This grouping of herrings in different classes according to size proves, I think, that each class of herring frequents its own particular locality. I may state that I noticed in a newspaper that one of our professors had examined herrings caught at the Hebrides, and found that they had one or two more joints in the backbone, and one or two more ribs in either side, than herrings caught near the mainland. This shows that there is a difference in the species.

The herring scarcely migratory.

In the early history of the herring fishing there were sometimes great quantities caught, although the boats and nets were deficient. The fishermen waited till the herrings went to the heads of the lochs in shallow water, where their capture was easy. Sometimes their nets were so full of herrings that their boats could not take more than half of them. But that involved no loss, as they could return when empty and haul the remainder. Nothing could go wrong with their nets, as they were generally trammelled in

Great quantities caught occasionally in early times.

Carries built.

sheltered places. Carries were built in some places, that is, a round circle was built with stones to the height of about four feet. At high water the tide overflowed the wall by some feet, and the herrings went in and got ebbed.

At Loch Slaben in September 1867 one hundred crans were taken in one of these old carries that had been kept in repair.

The beginning of this century.

About the beginning of this century there were large fleets of vessels, of from 30 to 150 tons burden, fitted out from our ports on the Clyde bound for the lochs in the west and north highlands to buy and cure. Others of them fished their cargoes. The herrings were all sold by the cran—a cran holding forty-five gallons.

Price and profits.

The average prices at the fishing stations were from 10*s.* to 15*s.* per cran.

Great profits were realized, as they were seldom sold in the market at less than £2 per barrel, and sometimes at a much higher figure. It was one of the staple trades of Greenock, and Rothsay is said to have been built on herring-bones. Ayr and other places contributed their fleets. Saltcoats, a small sea-port, sent out twelve to twenty vessels every season.

A town built on herring-bones.

Saltcoats.

The varying fortunes of the trade.

The vessels that bought generally made a good many runs in the season, if the fishing was good. Sometimes it proved a complete failure, and it was not an uncommon thing for a vessel to come home clean. I remember hearing of a vessel and her two fishing boats being away four months, and all for one barrel of herrings. Seasons so poor caused heavy loss to all concerned, and the Government saw that a branch of our industries was not improving. So they established a Board of Fishery, with powers to give grants to fishermen and to maintain law and order among them. One of the grants allowed was for

Government encouragement.

Board of Fishery.

the purpose of helping to repair broken boats. They offered a bounty for herrings fished a certain distance from shore. This deep-sea fishing, however, did not succeed, as fishermen had not made any improvement on their materials.

Government superintendence of fisheries.

At that time there was a heavy duty on salt, but salt used for curing herrings was relieved from taxation by Government. They also stationed fishery officers at the different fishing districts along our coasts, to look after fishermen's interests, and to settle any disputes among them, or between them and the buyers. They were there to see that no measures were used except those that bore the Crown brand.

Fishery officers appointed.

Their duties.

If herrings were sold by the hundred, forty-one casts and a tally were given, making in all one hundred and twenty-four herrings; this was the rule on all our coasts except at Howth, where forty-two casts were given, being three herrings more. If there was anything too difficult for these officers to settle, they referred it to headquarters. They were also experienced in curing, and had power to brand barrels, first having ascertained that they were well filled and properly cured. Curers who wanted the Crown brand had to pay a small fee for each barrel. Crown brands always drew a better price in home and foreign markets than individual or company brands. The Government also appointed a revenue cutter under the Board to attend the fishing fleet. Her duty was to see that each boat was properly lettered and numbered. These letters are the custom-house initials of the district to which the boat belongs.

Higher price drawn by Crown brand.

Revenue cutter and her duties.

Lettering and numbering of boats, and the advantages of the same.

The letters and numbers have proved very useful if any damage is done, such as fouling of boats or destruction of nets; the guilty parties can at once be found, if their official

Cutter goes to sea with the fleet.

number is known, by applying to the cutter. At the outside fishing stations she goes to sea every night along with the fishing fleet, not returning till the fleet is in harbour, and if any boat gets disabled she takes her in tow.

Improvement under Fishery Board.

Improved nets.

The fishing gradually improved under the Fishery Board, but it was not until about 1840 that a new epoch in the history of the herring fishing came about, when a Mr. Paterson patented a machine for making nets. He opened business at Musselburgh, and it was not long before he had a great many machines at work. The demand for these nets was very great, and has gone on steadily increasing. There are now a great number of these net factories over our land and our colonies, and other parts of the world are supplied with these far-famed nets. The machine nets are much fairer than those made by the hand, and consequently fished better. Instead of two hundred meshes, as before, they were increased to three hundred meshes deep, and in two or three years the trains increased in some cases to twenty pieces, each piece a hundred yards long and three hundred meshes deep. By this time there had been a great improvement on the boats. There was the "wherry," a good large-sized boat with a place for the crew to sleep in, but rather clumsy on the whole. The fishermen began to see that these boats were, although better than their predecessors, still unsuitable, and that they required something faster and abler. So they applied to Mr. Fife, boat-builder, Fairlie, father of the present Mr. Fife, yacht-builder there, who built a number of beautifully modelled fishing boats, some of them being 39 feet keel, 12 feet beam, and from 6 to 7 feet depth of hold. A plan was also invented for lowering the mast when the nets were shot, allowing them to be hauled much more easily. These boats sailed very fast, and suited our waters well;

Difference between hand and machine-made nets.

Nets enlarged.

Better boats, but not quite adequate.

Superior boat from Fairlie.

Plan for lowering sail.

but for the outside fishing nothing has yet been found to equal the Penzance and St. Ives luggers. I consider them far superior to the east of Scotland luggers; the fineness of their lines and the symmetry of their hulls make them more to resemble pleasure yachts than fishing boats. Some of our west of Scotland fishermen went to England and got boats of this class built to order, and their models were copied here for the mackerel and outside herring fishing. When fitted up with every appliance they cost nearly a thousand pounds. Our fishermen say they are really good boats, being so buoyant that they can weather almost any storm. The Isle of Man fishers seem to have a like good opinion of them, as all the old crafts have given way to them. The nets in these large boats are nearly all hauled by spring-backs, which are hove in by capstans or winches. Some of the largest boats indeed employ steam winches for this purpose. There is an improved winch, or, as fishermen call it, "iron man," which can be used without a spring-back, thus saving both labour and expense. The east coast fishermen regard it as a great improvement. The boats used at both the out and inside fishing are in the best of order, and whatever may be said to the contrary, the gear, sails, sleeping berths, cabins, &c., are all good. Speaking of boats and their furniture, I may state that it has often occurred to me that a part of the ballast carried on the outside of the boat would prove a protection against capsizing, and give more stowage for nets. That this would give extra speed is shown by the example of the yachts. Some people might object to this proposal on the ground that it would be unsuitable for dry harbours, but I cannot think that a few tons of iron bolted through the keel and through a good keelson would do any harm; and where the boats were always kept afloat, more could be added. I mention iron as

Penzance and St. Ives boat.

Adopted in Scotland.

Cost of these boats.

Nets in boats mentioned.

"Spring-backs."

"Iron man."

Boats and furniture in good order.

A suggestion.

being much less expensive than lead, and a casting of iron of the required mould could be made at any foundry.

Steamboats for fishing herring.

Steamboats for fishing herrings have been tried, but on account of the expense involved have hitherto been little better than failures. However, I think I am safe in saying that steam will yet become general in our herring fishery. When such improvements are being made in the departments of steam and steam engines, it is difficult to say what may not be in the future.

Steam fishing boats of great service at outside fishing.

Steam fishing boats would be of great service at our outside fishing grounds, which are sometimes far from harbours. The fleet sometimes goes as far as thirty or forty miles to sea, and then calm weather or headwinds are great drawbacks, especially with heavy hauls on board, as if they are not in time for that day's market the whole cargo is generally lost, and likewise the following night's fishing. I have seen, both at Stornoway and at Howth, as many as two nights' fishing lost in one week with calm weather.

Towing at Shields.

At Shields towing is becoming very common among the fishing fleet; a tug will engage to attend six fishing boats for a week for £30—£5 for each boat—thus showing that steam for herring fishing is much required; and it is to be hoped that, seeing steam trawlers have been so successful in other fishings, it will not be long before steam will be employed in this fishing also.

The year 1848 nets.
Cutch.
Tanning of nets.

Returning, in the matter of nets, to the year 1848, I may first mention that cutch was for some previous years used by fishermen in tanning nets, sails, &c. It is a great improvement on the old system of boiling oak or larch bark to draw the tanning qualities from them. I have seen days and nights occupied under the old system in doing an amount of work that with cutch can now be done in as many hours. The cutch has only to be melted in water

Advantages of "cutch."

and poured on the nets in a large tub till they are well saturated. This process is repeated once a month while the nets are new, afterwards the periods can be lengthened; but if nets have not been properly cured they will rot in a very short time.

Method of tanning by cutch.

Different substances, such as alum, oils, dyes, tar, have been tried for curing purposes, but nothing has yet been found to equal cutch.

Trawl-nets for "saithe."

Small trawl-nets were in use before the year I have mentioned, chiefly for fishing saithe. When these fish came close to the shore a few herrings were sometimes caught in this kind of trawl, but they were not looked after. About this time a fisherman belonging to Tarbet on Loch Fyne lost part of his drift-nets, so he made a large trawl of what remained.

Trawling for herrings commenced.

The first night he went out he secured a large haul of herrings with this net, about four hundred maise (five hundred herrings being a maise). This was a turning point on the road to improvement in our herring fishing, proving in this case the truth of the old adage, "Necessity is the mother of invention."

The writer's experience in 1849.

About this time a number of fishermen, the writer being one, began to make trawl-nets. In the beginning of 1849 I had in one haul upwards of three hundred crans of very large herrings (about five hundred to the cran). We drew, however, only a very small price for them, about 5*s.* a cran, as we did not know of any fresh market for them, and curers were afraid to buy, as they thought that trawled herrings would not cure. One buyer sent a few of them to England, and next year the result was that we had buyers from different parts of England, including London; prices rose to 7*s.* and 8*s.* per hundred, or from 35*s.* to 40*s.* per cran, showing that there must have been a great demand for large herrings in England.

English market opened.

Its beneficial results.

Before this the buying was mostly in the hands of the curers. The greater part of the herrings fished on the coasts of Scotland were cured and sent to the market and sold as new salt herrings. Grocery shops and other places of retail sold them by the pound, like any other commodity. The opening up of the English market to us, and the prices realized there, alarmed the curers, who thought this new method of fishing would hurt their trade, and they raised the hue and cry which several interested parties were not slow to take up. They said that trawling would soon rob our waters of all the mother herrings, and that herring fishing would soon become a thing of the past. Among the malcontents were fishermen, if we can call them fishermen—men who earned their livelihood as such in the summer months and returned to their trades or farms in the winter. In the newspapers articles appeared against trawling, and monster petitions, very largely signed by consumers, were presented to Parliament against the practice.

Trawling condemned by interested parties.

The consequence was that in 1860 an Act was passed making trawling illegal on the west coast of Scotland, also closing the time for fishing herrings from the 1st of February to the 1st of June.

Trawling forbidden by Act of Parliament.

Effects of this measure.

Many fishermen and their families were brought to poverty through this Act. The law was so strictly enforced that the fishermen were not allowed even to fish herrings for bait, and a substitute for this purpose could not be found. Her Majesty's Government at last became aware that some error had been committed and appointed a Commission to investigate. The Commission found that neither the quantity nor the quality had been produced since the passing of the Act already referred to; it was repealed as soon as possible and all restrictions removed. After this herring fishing began to flourish. Cotton twine was also

Government inquiry instituted.

Commission appointed to investigate.

Act repealed.

introduced for making nets, giving us a finer, cheaper, and more durable article than the hemp or flax nets that were formerly used.

Trawling now a recognised method.

Trawling has now become a recognised method, and the nets are enlarged to such an extent that, instead of being fifteen or eighteen score meshes deep, they are now from forty to fifty score meshes deep, and three hundred yards in length.

Trawl-nets.

Small screw-steamers employed by merchants.

Some of our fish merchants tried a small screw-steamer to attend trawlers and run with their herrings to the market, as heavy hauls were sometimes got early in the morning. This plan succeeded so well that we have now about a dozen screw-steamers in attendance. Tugs are sometimes chartered for the same purpose. These steamers are all capable of maintaining a high rate of speed, some of them reaching eleven or·twelve knots an hour, so that when they get their cargo of herrings on board they very soon reach Glasgow, often before the market is open. If the herrings will suit the English market they are sent off per rail as soon as possible, and will arrive in England in good condition. When the steamers are on the fishing ground they follow the fleet, and the fisherman who gets a good haul shows a signal with a light which the buyer understands. A steamer is soon on the spot, and when the price is agreed on, the work of transferring the herrings from the boats to the steamer is soon accomplished. The herrings are sold by the basket to further their dispatch.

The herrings transterred from boat to steamer.

Two boats for trawling.

It requires two boats for trawling, and each boat has a crew of four men. They generally put to sea in the afternoon to look for appearances. One man is always stationed at the bow to keep a look out, and the practised eye will at once detect the slightest appearance of herrings.

The "look-out."

Methods of discovering the presence of herrings.

There are different ways of discovering their whereabouts, sometimes by the presence of gulls, "gannets," porpoises, or the whale. But what is most depended on is what fishermen term "putting up." Bubbles are seen rising to the surface caused by the water passing through the gills of the herrings. The other appearances mentioned are often on small fry, but this of "putting up" seldom fails.

Trawling.

When seen the net is run out in the form of a half circle and hauled near the shore, if possible. The two ends of the net are hauled into the boat, forcing the herring into the centre or bag, where they can be taken out with baskets. Heavy fishings are also got in the middle of our channels by making a circle with this net.

Steam launches a benefit.

I think that steam launches would be a benefit for trawling purposes, as the boats are too large to be easily managed with oars, and they could go a greater distance in calm weather to look for herrings.

Drift-nets.

The take with drift-nets on the west of Scotland has been greatly on the increase for the last two or three seasons, while in Loch Hourn it has been unprecedented.

Successes of drift-net fishing.

Our east coasts both in England and Scotland have also done well, and good "takes" have been fished at the Orkneys. Some of the boats fished there two hundred crans in a few weeks.

Decrease at various places not to be attributed to over-fishing.

At Howth and Ardglass it has fallen off greatly, and no reason can be given for it. It cannot, however, I think, be attributed to over-fishing.

Sudden movements of herrings.

In my own experience I have observed that herrings will frequent certain grounds for a number of years, then suddenly leave, to return again when not expected.

Recent improvement on drift-net.

An improvement has of recent years been made on the drift-net which I cannot explain better than by saying that the net is turned upside down. The strong rope is underneath, and a small cord or rope is run along the upper edge well corked, so that the net can be kept on or near the surface. This plan will do well where herrings are fished in the tracks of steamers. Some of these, as well as sailing vessels, draw twenty-four feet water, so fishermen must have their nets fully that distance below the surface to allow them to pass; so if the herrings are near the surface the greater part of the nets will be beneath them. When the small rope is uppermost, steamers or sailing vessels passing over the nets will only break the small rope, doing very little damage, as the strong rope will keep the whole fleet of nets together. By this means the herrings can be fished near the surface. This inverted net was first used on the east coast of Scotland, where it has now become general. A few of the west coast fishermen have adopted the plan with success.

Inverted net first used on east coast of Scotland.

At Ballantrae a different kind of net is used when the herrings are on the banks spawning. These nets are called "bottom nets," and are about eighty meshes deep. A rope is put on both edges; the upper one is well corked, while on the one underneath stones are tied to keep the nets at the bottom, the stones being some distance apart. A large stone is attached to either end for moorings. I have seen these narrow strips of nets completely filled with herrings, and when this is the case it is with the greatest difficulty that the crew can get them hauled.

Nets at Ballantrae.

"Bottom" nets.

It is to these banks that the greater part of the herrings on the west coast of Scotland resort to spawn, and I may add from the English Channel also, as great shoals are seen coming from the south. The herrings begin to gather there about the 1st of January, and by the middle of February the greater part of the body has arrived. They begin to spawn about the end of February, and are generally spawned and away by the middle of March.

Banks at Ballantrae.

Spawning.

Herrings do not go in a body after spawning, but scatter, keeping near the surface to get food, and if it is mild weather they are in good condition by the middle of June.

Ancient origin of Ballantrae fishing.

The Ballantrae fishing is of long standing—some old papers turned up not long ago showing that herrings were fished there as far back as the 15th century. But it is only of recent years that it has become of such importance. As many as five hundred boats from different parts are fishing there every season; the majority are trawling, and the greater part doing well, as the prices are generally good—much better than in the summer season. The most of these herrings are sent per rail to England.

Its importance.

Fishing at spawning time.

Some think that herrings should not be fished when near spawning, as it will affect our future fishing, and that they are not in a good condition for food. Regarding the last statement I would say that the prices realized for them show that they cannot be in a bad condition, and the idea that man may reduce the quantity of herrings in the sea is simply absurd. As many as 68,608 eggs have been counted in a single female, and if only a tithe of them would come to maturity our waters would get completely filled.

Herrings the food of other fish.

All sorts or kinds of fish in our waters will eat herrings, and they constitute the chief food of the most of them. It is enormous the amount of herrings destroyed by other fish for food. I saw a fish caught about twenty lbs. weight, and in its stomach were one hundred small herrings about two inches in length. Now if a single fish will consume that quantity at one meal what must the total consumption be? It is well known that sea-fowl also live almost entirely on herring, so that the herrings fished by man must be only a small fraction compared with what is destroyed otherwise.

Sea-fowl also live on herrings.

Abundance of herrings at Ayr, 1796.

I remember seeing in an old Edinburgh publication that on the 20th of August, 1796, the herrings were so plentiful along the shores at Ayr that the people got a good supply by means of baskets. This is not at all wonderful, as three years ago we lifted a good many on board with baskets in deep water off Ballantrae.

Abundance in recent years.

Writers differ widely in their opinions regarding the time required to bring a herring to maturity—most of them thinking that it takes years. Fishermen, too, I observe, are undecided on the point, but recent experiments in Rothesay Aquarium will throw some light on the subject. Herrings put in there a few inches long became full grown in less than eighteen months, though they did not fill properly. It may be supposed that if in confinement herrings grow so quickly, maturity must be reached much earlier in the open sea, where proper food can be got. At Ballantrae, in 1879, I assisted Mr. Melville, who was fishery officer there at that time, in procuring some herring spawn for the late Mr. Frank Buckland, Her Majesty's Inspector of Salmon Fisheries. He wished to ascertain the time taken by the herring to arrive at maturity. Most likely the spawn died before reaching Mr. Buckland, as his investigation was unsuccessful. The bottles employed were small, holding only two pints or little more. These were filled three parts with water, and pieces of seaweed, to which the spawn had adhered, were also put into the bottles, which were closed by covering their mouths with thick paper secured with gum, no air being admitted. The spawn would be at least two hours out of water before being placed in bottles. Had larger bottles been used, the spawn placed immediately in them and the cover perforated, the result might perhaps have been more satisfactory. It is very beautiful to see the spawn on a broad leaf of seaweed. There is no crowding, each egg or particle is placed in the nicest precision, and there is ample space to allow the egg to expand as the young herring is

Maturity of the herring.

Rothesay Aquarium.

Growth of the herring.

Mr. Buckland's investigation.

A failure.

Probable causes of the failure.

Beauty of spawn on seaweed.

Early development.

forming. I have seen head and eyes distinctly developed five or six days after being spawned.

Growth of herrings.

If their growth could be ascertained as easily as that of the salmon, it would most likely be found that the herring, to arrive at maturity, takes months instead of years, as is generally supposed at present.

Two classes of herrings.

Stomach.

It is universally thought that there are two classes of herrings, the "Gutpock," or herring that feeds, and the herring that derives its nourishment from water only. All herrings, however, must eat till they are full grown, and after spawning they eat till they become "prime," that is, when they become well filled with fat. If this fat was examined the stomach would be found in the centre of it, completely closed up.

Weather—its effects.

The food of herrings.

I believe that warm weather is beneficial for fishing, especially in summer, as heat is requisite for bringing to life that small fry on which herrings feed. This fry is scarcely discernible, but when sailing over a quantity of it the water has a reddish appearance. It is generally near the surface, and if drift-nets are run out through this, good fishings are generally got if herrings are there in search of their food.

Personal experience.

Food of herrings.

Summer life.

Jelly-fish.

In my own experience at different fishing grounds I have always found that the stomachs of prime herrings when examined were empty, and that their general food was that small animalculæ which I have just referred to, and which, depending on the warmth of the season, is to be found in the end of April or the beginning of May. This animalculæ or crustacea comes into life with the increasing heat of the water, and dies when the cold comes, the quantity always being in proportion to the degree of heat. Another instance of this short summer life is to be found in the jelly-fish, which appears in the beginning of summer, affords food and shelter to the young whiting, and dies on the approach of winter. A warm summer must therefore, as I said before, have a beneficial influence on the fishing, as it is generally the end of summer when herrings become "prime." If, however, the herrings cannot get this food, which appears to be specially prepared for them, they will take shrimps or other small fish. It is in August that our lochs teem with herrings, especially our deep-water lochs, and it is there that herrings get that fine flavour for which Loch Fyne herrings are so much famed. When fishing in Loch Fyne I have seen the nets lowered twenty, forty, and even fifty fathoms below the surface to get these fine herrings. In Loch Hourn and all other deep-water lochs along our coasts the herrings improve in quality very rapidly. About August herrings gather into large bodies, and if broken up they immediately close again so as to protect themselves against their enemies. These shoals can only be attacked on the flanks, as when alarmed the body becomes so dense that the assailant is in danger of being choked by the multitudes. It is for such shoals that trawlers naturally watch. If they are not seen in the daytime by the appearances I have already described there are other ways of finding them at night. If it is a moonlight night fishermen watch eagerly for them rushing or "putting up" on the surface of the water.

A warm summer beneficial.

Other food.

Deep-water lochs.

Density of shoals.

The shoals and the trawlers.

"Putting up."

But when the night is dark, a man is stationed on the look-out, and by striking on the gunwale of the boat, the herrings can easily be seen moving by means of the phosphorus that is in the water. If herrings are plentiful they will make such a flame that it will light up all around the boat when a heavy stroke is given on the gunwale. I saw a statement by one of our professors, to the effect that he had examined the head of a herring and that it con-

A dark night.

Phosphorus.

Herring having no organ of hearing.

tained no organ of hearing. If this be the case the other senses must be very acute, as at the slightest noise they will swim away, though it be a gun fired at a considerable distance. The same appearances are, of course, looked for by drift-net fishermen.

Morning fishing.

Fishers change their positions.

Moonlight fishing.

Enemies of fishers.

Dog-fish.

Porpoise.

Nets attacked.

The basking shark.

Destruction of basking shark among nets.

It is in the evening that herrings generally "mesh," before the "fire," as the fishermen term it, comes into the water. The reason of this is that herrings notice the nets by the phosphorescent light and avoid them. If the fishing is light and the night long the fishers generally haul in their nets and look somewhere else for herrings, so that they may have another chance before the break of day. It is different altogether when there is moonlight, as then herrings often net all night. Hence the line in the old song, "The herring loves the merry moonlight." Drift-net fishermen have many enemies which prey on the herrings caught in their nets. During some seasons the "dog-fish" is very plentiful, and very destructive, doing great damage to the nets as well as abstracting the herrings. Porpoises too, in large numbers, frequent our waters, and, when they discover nets well-fished, the fishermen have but a poor chance, as the nets are cleaned by them faster than they can be hauled. There are many other enemies among the large fish which do a great amount of damage, but the most destructive of them all is the basking shark or sunfish. It visits our coasts in the beginning of summer and leaves at its close. Fishermen greatly dread this monster, as it often carries away their nets when it gets entangled in them, or if the nets are left they are so badly torn that they seldom can be mended.

Harpooning the "shark."

In the beginning of this century the harpooning of the basking shark was common on our coasts, and it is said to have been very remunerative, as an immense quantity of

Harpooning the "shark" recommended.

oil as obtained from its liver. I mention this because I think that not only would it be profitable to pursue this fishing at the present day, but it might help to rid the waters of one of the drift-net fisherman's worst enemies. It may be the scarcity of the fish was the cause of this fishing being discontinued, but its reappearance in greater numbers during the past ten or twelve years might warrant fishermen in turning their attention to the subject. It would not be difficult to harpoon these fishes, as they will remain on the surface a long time, allowing a boat to come up quite close to them before going down.

Experience at Ballantrae. Year 1883.

Gales in January and February.

Drift-nets only of use.

Price.

Improvement in March.

Engagement of trawlers for Ireland.

Having just returned from Ballantrae (March 20, 1883), I will add my experience of the year's fishing there. It was the general opinion of all fishermen that there were more herrings on the Ballantrae Banks than had been there during any previous season in their experience. The gales, however, in January and February were very much against the fishing; it was but seldom that boats could go to sea, and when they did get out it was only with the drift-net that boats did any good. I have explained before that the trawl boats have to be pulled with oars while making a ring, and the drift-nets are run out in a straight line before the wind, consequently there were very few herrings landed, and prices ran as high as £5 per cran. The 1st of March brought a change for the better, and there were landed on one day seven thousand crans; prices ranging from 15*s.* to 20*s.* per cran, mostly trawled. Some of our trawlers are engaged by an English firm to trawl during the first two months of summer on any part of the Irish coast from Innistrahull to Ardglass. They are to be attended by steamers to take the herrings to market. The trawl has never been used before in this district for herring fishing.

Shetland and the trawl.

In conversation with some fishermen who had been fishing among the Shetland Islands during last summer, I heard it stated that trawling, if adopted there, would be a success, as the herrings were close inshore. The only difficulty would lie in getting the trawl boats there, on account of the great distance.

Source of wealth to England.

I need not say anything here of what a great source of wealth the herring fishery is to our country, as that is well known from the figures published regarding our exports, not to speak of the immense quantities consumed at home. It would not be possible to give a correct statement of what is used at home; there are so many bye-ports and creeks where herrings are landed.

"Catch" greater.

No danger of reduction of supply.

Better methods in future.

It is acknowledged by all, including those who would put restrictions on engines used for fishing, that the "catch" of herrings is greatly on the increase. I have forty years' experience, and I see no danger of reducing the quantity of herrings in our waters. All the improvements on our material have been a benefit both to fisher and consumer, and, judging the future by the past, we may expect greater improvements and better methods still in capturing the finny tribes. Restrictions on any industry are hurtful, but they are particularly so when applied to herring fishing.

Curing.

"Bloater," "kipper," &c.

Before closing I may mention that the system of curing for the home market is now nearly supplanted by better methods of preparing herring for food. There is the "bloater" and the "kipper," and many other ways of making them more palatable than having them packed in barrels and covered with pickle.

Railways.

Our railways are also a great advantage to fishers, branches being laid to all the principal parts of the coast, and steamers run in connection with them to the islands, bringing as it were the remotest stations near, so that

England can in a few hours get a fresh supply from the far North.

Number of persons dependent on fishing.

It is computed that in Scotland alone upwards of one hundred thousand persons depend on the fishing for their support, and if England and Ireland were added thereto, the number would be immense. It is well known that our navy derives a great many of her seamen from our fishing population, and so does our merchant service, proving that Great Britain's fisheries are most beneficial to her, both directly and indirectly.

Benefit of fisheries for the navy.

Government's interest in fishing.

Loyalty of fishers.

Our Government has always taken a deep interest in the fisheries of the country, and fishermen as a rule know this and appreciate it. They are a loyal race, and, if need be, they would, in the words of the poet:—

"Stand
A wall of fire around our much-loved isle."

THE

HERRING FISHERIES.

> " *Who hath despised the day of small things?*" *for while our fishermen went in search of whales, the Dutch fishermen came in search of herrings.*—[R. J. MUNRO.]

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THE HERRING FISHERIES.

PART I.

THE herring fisheries form one of the greatest commercial sea enterprises at home or abroad as a ready source of wealth. Royalty has aided its development, for it is branded from olden time by the legislative care of kings and governments. In England this fishery was pursued at a very early period. Yarmouth was taxed to the amount of ten thousand herrings for his Majesty King Henry I. Edward III. encouraged and fostered this industry with money and wise legislation. In Scotland, also, it has had the patronage of royalty, especially from their Majesties James V. and VI. And to this present time Parliament has passed many Acts and inquiries affecting our herring fisheries.

The British herring fishery is inaugurated at the Hebrides in the month of May, and closes with the autumn and winter fishery at Yarmouth (with some exceptions in Scotland). Owing to this, we have a spring, summer, autumn, and winter fishery, and it is also between the winter and spring seasons that a close time for herring should exist.

Yarmouth is the central fishing station for this great industry on the east coast of England. Wick, Peterhead, and Fraserburgh, are the great fishing stations for the east coast of Scotland, but the best fishing grounds are found on the west coast.

Immature herring, which is really summer fry seeking the ocean waters, are found in the Atlantic in vast shoals, and many fishermen traffic with these comparatively worthless fish as early as the month of April. In the interests of the Lewis fishermen alone a close time is needed, and this is asked to be from the 15th of March to the 15th of May.

From Lewis in the Hebrides, Skye, Fort William, and other adjacent districts, the boats put out for the herring fishery. Sometimes after toiling all night the boats will come home clean, but more generally the season is favourable and propitious; for instance, the records for last year (1882) "Stornoway Herring Fishing" show great success attending the fishermen's efforts. In the beginning of May for that year "shots" of from thirty to forty "crans" were very common, while several were as high as fifty and sixty-three crans. Whereas at Barra, in the Hebrides, very poor "catches" were got, at least for the opening season of that year. Again, as we shall have occasion to notice, a bad opening may end in the same place with a perfect harvest of fish, and *vice versâ*, or the season may prove a very fluctuating one at almost any station or district. Sometimes a "total failure," and often a "good season," all through the different months.

The Orkney and Shetland Isles districts follow suit, passing round the north-east coast until it (the season) reaches the central and main fishing stations for Scotland, which is early in July.

"The Herring Fishery" now takes the precedence over the "White Fish Fishery," although both are well represented from the east coast fishing stations, and it ought to be noticed that the best bait for catching our white fish is herring itself.

Many stations on the east coast are now actively engaged from July to September, and in the latter month the northern districts are practically closed for the season, and the engagements for the east coast fishermen also end in September. For all that, the fishery is still pursued from the various stations south-east of the Firth of Forth, known as the Berwickshire Coast Fishing Stations, and large additions of mixed quality are added to the season's catch.

About this time the herrings come inshore to spawn along the coasts of Northumberland, and of course the fishermen of this part have their rightful share in the fishery, and inaugurate the autumn and winter east coast of England herring fishery.

The Tyne trawlers of Newcastle and Hull boats follow out the fishery; and with reference to the last-named town or fishing district, it may be suitable to mention at this stage a novel invention of "curing herrings by machinery," introduced by Mr. George Leach of Hull, by which he estimates a barrel of herrings can be bloated at a cost of *6d.*, as against 1*s.* 9*d.* the present cost. The plan may be described as a successive process of drying, smoking, and cooling, by carriage from the cleaning room to the grills or wire-work trays. By passing up through a series of chambers, and down again in a zig-zag direction, they are operated upon by the agency of heat, smoke, and cold, and on their coming down to the reception table at the end of the first journey, they are ready for packing.

The "Newcastle kipper" also deserves notice, as it is competing favourably against the celebrated "Yarmouth bloater" in the Metropolis, and was introduced at first by the late Mr. John Woodger, of Newcastle and Great Yarmouth.

Filey, off Flamborough Head, is the next and most important station, and exclusive of Great Yarmouth there are very large captures taken by the fishermen of Lowestoft, Folkestone, and Hastings, and boats come from the north of Scotland to share in the English fishery, although there is a winter fishery pursued in Scotland besides that of Yarmouth.

While in this vicinity we may notice the abundance of "whitebait" found during summer in the Thames, Humber, and other brackish waters near the sea coast, and that it really is the young of the herring or herring fry.

It ought also to be noticed that the smallest herrings are caught off this coast, known as "longshorers," and are really the finest caught on the east coast of England. The takes of herring by the Tyne and North Shields fishing boats for August, 1882, were so large that the "railway company had to put on extra special trains" for their transit to the Metropolis.

Coming round to the west coast, *viâ* Solway Firth and Ayrshire districts, we enter a "New Year," and they are still fishing for the best herrings that are found on any part of the British coasts. Loch Broom, Loch Horn, Loch Fyne, and many other places, have only to be mentioned, as the celebrated resorts for the best quality of herring. Indeed, during the month of October for last year (1882), extraordinary takes of herring, and such as have not been for many years, were found at Astle Bay, near the head of Ardlamont, Rothsay; from six hundred to seven hundred crans landed, and for the most part sent to England.

At Girvan, during January and February, the fishery is still pursued, and from many parts of the opposite coast, including Newhaven, fishermen come and share in the closing hauls for the season, and neither for quality or quantity can any fishing grounds equal those in the west of Scotland; but practically there is no close of the British herring fishery, although the great season is from July to September.

Yarmouth, the headquarters for the English fishery, usually commences operations at the close of the east coast fishery for Scotland. In the beginning of October, a fleet of, or more than, five hundred vessels set out to the fishing grounds. A Yarmouth lugger is better adapted for the business, and less dangerous, than the open boats of Scotland, except where the "hauling in" of the nets are concerned. This is obviated in the case of Yarmouth boats by using smaller nets, as when searching for fish the men may shoot and re-shoot them quite easily. Nets range from one hundred to one hundred and forty for each boat, and the nets are forty-eight feet long, and thirty feet deep. A Yarmouth lugger may cost from £700 to £1000, and is equipped for cargo and partial curage, carrying barrels, salt, and other essentials. The boats average fifty feet long, and the crew about fifteen men. Both the fishery and the curing processes connected with it are very carefully conducted. Buoys, in the shape of small barrels, show the position of the nets, and these buoys are painted according to the ship's name and port to which they belong, and at night lights are used to prevent collisions with the boats.

Although there is a great and increasing demand for fresh herring, especially in the earlier part of the season, the greater portion of the season's catches is cured. The broken fish is sold in hundreds of tons for manure, and sometimes at as low a figure as 20*s*. a ton. The curing-houses usually consist of two interior divisions, one for receiving and cleaning the fish, and the other to smoke them. The smoke-house, from bottom to top, has a series of woodwork called "tiers," on which the loaded spits hang, and the women are very dexterous in their manipulation, spitting a last in one day's time, or something like thirteen thousand herrings. Different effects follow both as to colour and curing, according to the length of time the fish are exposed to the action of heat. The names themselves indicate this, as they are called "Bloaters," "Straitsmen," "Reds," and "Blacks."

At Yarmouth, billets of oak wood are used for smoking the fish, but in the west of Scotland brushwood and furze is made use of, but in all cases of smoked fish oak wood is best for practical purposes, though pine wood is said to give the best flavour; and a great deal depends on the fish itself, and dispatch in curing them, hence the reason why the boats carry salt and other necessaries with them. The Yarmouth "bloater" is a familiar speciality, only hanging till it swells or "bloats." It is often packed and ready for transmission the night following its capture.

The Yarmouth fishermen count their herrings by "swill-baskets;" thus twenty swills make one last, supposed to contain six hundred and sixty herrings in each swill. Again, four herrings make a "warp," thirty-three warps go to a "hundred;" in other words, one hundred and thirty-two fish.

Great Yarmouth, if not itself the earliest station of which we have any record, at least occupies the sand-bank which appeared about the same time as the Roman legions. This sand-bank, "Cerdick shore," derives its name from Cerdick the Saxon, who landed here in the year 495.

Not only were the Romans great lovers of fish, but especially so to a dish of herrings, and their encampment the mouth of the Yare still remains in proximity to

Great Yarmouth. It is said that our ancient fishermen supplied this "garianonum" or encampment with herring.

In 670 a tax upon the herring fishery is mentioned, and this tax was commonly known as "herring silver." Another reference in details is dated also with the history of Evesham Monastery, founded in 709. We also find that an annual tribute of herrings, varying from thirty thousand to sixty thousand fish, was paid as rent to one Hugh de Montford, of Suffolk Manors. The "free fair" of Yarmouth, or herring market, was attended by many foreign fishermen,and this "free fair" lasted for forty days, ending November 11th.

We have already noticed the tax paid to King Henry I., and in 1209 we find King John granting a charter to Yarmouth, on condition that the burgesses provide his Majesty with fifty-seven ships for forty days at their own charge, as often as he should need them, for hostile occasions, and also that they pay an annual fee of £55 to farm rent for ever.

The Abbot of St. Albans was a large patroniser at the herring market, and some idea may be gathered from the fact that his agents employed "seven stout and handsome horses" in carting his herrings for storage. These latter he sold over again at a profit, after the free fair was over.

Passing by many interesting records, we find that the prefix "Great" was added to Yarmouth in the reign of Henry III.; and a noble provision in Magna Charta enacted that "all merchants may with security and safety go out of England, and come into England, and stay and pass through England, by land and water, to buy and to sell, without any evil tolls, paying the ancient and rightful dues, except in time of war."

The Statute of Herrings passed in 1357 enacted, "That all herrings should be bought and sold in the haven of Great Yarmouth during the fair, not at sea, or within a radius of seven miles from the port of Great Yarmouth, and that the last of fresh herring should not be more than 40*s*., and that two lasts of fresh shotten herring should only be equal to the last of fresh full herring.

"That all sales should be contracted between sunrise and sunset, that six score should be the hundred of herrings, and the last to be ten thousand.

"Further, that the merchants of Yarmouth and Metropolis or elsewhere sell the thousand of herring to the public after the price rate of the last, and that the Yarmouth dealers should sell the last of red herring within forty days, at and not exceeding half a mark of gain above 40*s*. paid for fresh," &c.

These provisions show how important was the acknowledged position of Yarmouth in its relations to the herring fishery.

The herrings appear on the Irish coast in June, and just at the close of the mackerel fishery, and they are captured both by the Irish and Manx fishermen. Immense shoals now commence their journey down the west coast of England, literally darkening the sea with their numbers and density. They have been known to extend a distance of six miles off the Isle of Man. Great quantities are caught in Cardigan Bay, Swansea Bay, and St. Ives Bay. It may be noticed that the west coast of England fishery commences about the same time as the east coast of Scotland, and also that the Irish herring fisheries are almost a name; for instead of working a coast that may be said to superabound with this fish, they are content to derive supplies from the north of Scotland.

Sprats (*Clupea sprattus*) are caught in abundance off the Cornwall coast, and also in the south of England; and the pilchard fishery of St. Ives is still one of the most important of any connected with the *Clupeidæ* family. The season is between August and September, and upwards of sixty years ago large quantities were caught in the Firth of Forth and other estuaries of Scotland. At present this fishery is confined to the coast of Cornwall. The mode of capture is to encircle the fish with a net called the "seine-net," requiring twenty men to each net. Including boats, netting, and gearage, the cost is nearly £1500. When cured for exportation they are carried and laid in "bulk," that is, laid in layers of salt and fish alternately, until the pile is finished. In about a month sufficient oil is extracted to allow of their being packed; and this, the last process, requires a good deal of pressing before "heading" up the casks. On this account a pressing-machine is used for three times to each barrel or cask before heading it up. The Irish coast and west of England herring fishery can show records of national importance, and charters relative to it, as far back as the year 1202.

The French herring fishery has a history of its own, and is carried out not only on its own shores, but to a large extent in English waters. Prior to the Anglo-Franco war, more than three hundred French vessels pursued the fishery at Yarmouth Sands, and at this time they were considered the best fishers in the world.

Open ruptures were common among different nationalities through fishermen trespassing in each other's waters, and in 1468 a mutual treaty was made between European powers that fishermen should be allowed to fish without hindrance in any water.

The free fair of Yarmouth drew many French fishermen, and others likewise, to vend their produce in England. Many of the traditions connected with Great Yarmouth are strangely linked with names that bespeak French or Norman extraction.

Peter Chivalier, a Yarmouth merchant, is credited with discovering how to cure herrings in salt, and his method was followed up by one Peter de Ferars. Louis VII. of France passed an edict that only mackerel and salted herrings might be purchased at Estampes; this was in the year 1155.

It was at Kiel Bay that the food of the herring was popularly demonstrated to be of a certain kind. Although M. Mobins is not the only naturalist who has asserted this, still we are indebted to the French coast fishery for those facts which relate to herring food. In the year 1383 immense shoals were caught off the French coasts, and sometimes the schools of herring are so large that the boats are unable to take all the herring which "strike."

During the season of 1880, which was a remarkable one in all quarters, one French fisherman drew thirty-five lasts, and it is asserted that another on one occasion caught more than fifty lasts, or 700,000 herrings.

And the takes of herring by French fishermen for 1880–81 are recorded to be above the usual average.

The sprat or sardine fishery of France is the most extensive of any that seek that species of the herring; and young herring-fry and pilchards form a large percentage of the true sardine; and it may be admitted that, in other points connected with fish culture and fish acclimatization, we should do well to follow up the footsteps of France.

The herrings appear on the north-western shores of Iceland from May to September; sometimes later, never sooner, or very rarely so, and always found in September in the eastern fjords ; they are never found on the south and south-west coasts.

The shoals, in their migration to the north and north-east coasts of Iceland, sweep into those fjords possessing deep water and feeding properties, and so we find them abundantly in such fjords as Eskjfjord or Seydisfjord.

The fishery is carried on in these fjords, and principally by Norwegian fishermen, who stay for the season, curing the fish at the various stations or wooden sheds erected for the purpose.

The Norwegian boats are larger than the Icelandic boats, but yet smaller than those of the east coast of Scotland.

The fishing is by means of the seine-net, and in large takes the ends of the net are anchored ashore, when the operations may now be compared to the pilchard fishery of Cornwall, the fish being taken out as they can cure them. The nets vary in size to suit the varying depths, with a mesh of half an inch.

The best kinds of white fish are found here in conjunction with the herring, besides many of the numerous enemies that pursue the shoals, such as sharks, "herring whalers," catfish, wolf-fish, sea-gulls, &c., &c., and by the end of the season, or at least in September, herring nearly one pound in weight are taken, and such usually measure fourteen inches in length. It ought to be noticed that medium herring, or even the small ones, are preferable in quality.

As stated, the Icelanders do not follow out the herring fishery, and although Norway takes a leading share in this fishery, the east coast is represented in these waters through the firm of Messrs. Slimon, Leith.

Shetland is realising the growing importance of the herring fishery, for although they pursued the cod fishery with skiffs in comparison to the open boats, or even the double-decked mainland Scotch boats, they have not only increased the number and size of the latter, but solely with the view to prosecute the herring fishery; as an instance, the following statistics will show this. In 1880, the number of boats was increased to 217. The success attending the fishermen for that year led to an increase of boats, which rose to 276 as against 217 for the year 1881; also 125 large decked boats as against 72; and in the year 1879 Shetland only possessed six large herring boats: this favourable account for this district is still on the increase. The terrible north-west gale which broke over the Shetland district on July 20, 1881, cost them the loss of ten boats and fifty-eight lives; but as many will remember, the season was a bad one all through; many valuable lives were lost, for on the east coast alone not less than one hundred and thirty-four fishermen perished within sight of home and friends. A fisherman's wife, writing about Shetland, says, "Instead of a fund for widows and orphans, could something not be done to save us being made such?"

The "haafs," or deep-sea boats of Shetland, are really what we termed them, "skiffs," barely able to carry 60 cwt. of fish; they resemble the Norwegian yawl, but having a greater spring from stem to stern.

Round the many points and promontories, and between the islands, numerous and dangerous tideways run at a fearful velocity. "Cutting the string" means crossing these tideways, and this is only attempted at slack tides; when it has to be performed at full tides, the danger will to some extent be understood; the livers of the fish are crushed to prevent the waves breaking called "lioom;" when this so-called "cutting the string" is not attempted, then they scud before the wind under bare poles.

It would prove an advantage to all connected were the jacket-net more universally adopted at the herring fishing, as it saves time by telling whether herring are about, and at what depth, and a thermometer is also attached to show the temperature of the water.

Fishermen would be better prepared for any emergency if they would only provide themselves with a portable life-jacket, which could be inflated before taking the harbour in a storm.

Although the Norwegian schooners run to Iceland for herrings, their own fisheries, exclusive of Sweden and Denmark, are of considerable importance and value. The jagts or yawls fish in the numerous fjords, which in some cases extend inland for a hundred miles, with frowning mountains overhanging their sides, or sweeping cataracts disgorging themselves into the basin below, and sea-gulls helping themselves to the finny wealth from these waters. The depth close inshore of some fjords is one hundred fathoms, and even deeper in some cases.

The creeks of the west coast are subject to sudden squalls, which, through the intervening mountainous background, sweep down unperceived. The herring shoals sweep into and from these fjords proceeding towards Stavangar and the Naze. From Bodo and along the chain of islands known as Loffoden Islands the fishery is prosecuted, and as a feeding ground these fjords resemble our own west coast of Scotland.

Along the Swedish coast there are also rocky islands of varying length and breadth, with a fisherman's house upon one or other of them, and a creek or fissure serving the purpose of a harbour. The fishery is pursued at various seasons of the year from the Cattegat grounds into the northern Atlantic; but there are very important stations and fishing districts along the south coast, and the sprat and anchovy fisheries form an independent nucleus of wealth.

Their mode of curing is peculiar and unique. Besides curing sprats (*à la* sardine), we may get herrings skinned and boned, or skinned, boned, and marinated, that is, cooked and potted either in vinegar or glacialine, or we can get the "brack-water herring" done up in the same manner.

Perhaps we should state here that these coasts exemplify a curious feature in marine life, viz. herrings living in fresh water, being unable, through physical features of the coast, to reach the Arctic Ocean.

There are also large companies in Norway and Sweden which cure and export herrings on a very large scale, such as the Stavanger Preserving Company, Nordlands Preserving Company, Bodo, Norway, &c.

Before the eighteenth century Swedish records show that their home and foreign trade surpassed the Scottish fishery. Vast quantities were boiled down for oil, and this over and above an immense quantity consumed at home besides exportation. The same is truer still in regard to Holland, for even before the sixteenth century their herring fishery was the best developed and most extensive one known, until it was prohibited in 1625 from fishing off our coasts unless provided with a royal licence. About this time a British Fishing Association was suggested by Coke as a mutual aid in withstanding the encroachments from Dutch and French fishermen. Notwithstanding both the Dutch and French fleets continued prosecuting the fishery in sight of Yarmouth, and the Dutch fleet were guarded by war-ships. The war between France and Holland was the first perceptible step that led to a decrease in her fisheries; this was in 1702, and through which she lost four hundred of large sized Dutch busses.

The invention of curing herrings is attributed to one Beukelsz, who died in 1397, and it is recorded that the Emperor Charles V. paid a royal compliment by visiting his tomb.

It seems as if the *Clupeidæ* family had found out the truth, for some time back, in that term which is so well known, viz. " Amsterdam is built on herring bones." At least the herring fishery of Holland is not what it used to be, principally owing to the scarcity of fish, yet it was Holland who inaugurated and developed this fishery into a system of commerce, though there is good reason for giving equal or even pre-historic precedence to Scotland, who allowed it to decline.

The Dutch are famed for the scrupulous care in every incident connected with the fishery and curing operations. They have two kinds of fish and two kinds of salt; this latter commodity is brought from Spain, the barrels must be of a certain kind, the mode of eviscerating must be up to the standard, and from beginning to end every detail must be complied with ere one officer would dare to stamp them as Dutch cured herrings.

We might notice here that the word "herring" was derived from the German " Heer," an army, in relation to the moving shoals in their progress or migration.

At Nova Scotia, Newfoundland, Carolina and Virginia, and other parts of the coast of America, an extensive herring fishery is followed out, and the same physical aspects and feeding properties through the rivers and other agencies mark out these grounds as a resort for all kinds of fish.

The season for herring begins in April, when the first "run" arrives, named "Granville fish," from the course they take past that township. The May herring are spent fish, and, of course, inferior in quality. The season lasts to October, when, between the early takes of large herring, the celebrated Nova Scotia sprats form the closing hauls. Herrings of superior quality are found in the numerous bays of Nova Scotia and Newfoundland during summer and autumn, but, as we find on our own coasts, and, indeed, more or less everywhere, the herring shoals will disappear for a season, or seasons, invariably returning again to their old haunts. The sprats or herrings are cured by smoking, and one speciality in this class of cured fish is to remove the bones before drying them.

The herring species are extremely large in the North Atlantic waters. The *Clupea elongata* measures 15 inches in length and over 5 inches at its broadest part, and these, perhaps, are the extreme limits. They are very abundant during the season, and the smelts (*Osmerus viridescens*) are so abundant during the winter that they are invariably used for manuring purposes, notwithstanding their delicious flavour and edible qualities. Splendid specimens of the genus *Alosa tyrannus* are found here, and, if possible, they are even more extensively used to enrich the earth. The best specimens of our white fish are found here, and, considering the quality of their food so largely represented by the herring species, we need not search further for reasons. It is recorded that in the year 1796 a vast quantity of herring was frozen into a solid mass in one of the weirs of Nova Scotia.

As we have stated, the smallest herrings are those caught off the Norfolk coast, known as "long-shorers," and the largest specimens are found along and off the coasts of Nova Scotia, Newfoundland, Labrador, and vicinity of North America. The herring is widely distributed, abounding in the White Sea, Baltic, Zuider Zee, and in the Black and Caspian Seas. The Persians call their herring royal fish. It is a familiar favourite on all parts of the British coast, through Europe, and all parts of the northern hemisphere.

Large quantities of special cured herring are exported direct to our Australian colonies, and it is an expressed wish from the Antipodes that some effort for introducing the *Clupea harengus* be made.

Abundant as the herring is, there is good reason to believe that it may be made a common commodity wherever the conditions necessary to its habits exist; these conditions do exist particularly around the British coast, and very specially in the western islands of Scotland.

The herring is most abundant on the British coasts, in comparison to any other coast throughout the world, and perhaps this is the cause above all others why Great Britain possesses the best herring fisheries in the world.

PART II.

IN the district of Girvan there is a small village named Ballantrae, and the fishing-bed is on the "Ballantrae banks." Upon these banks the herring come regularly, and have done so for centuries, during the month of February, as a rule. This year (1883) has been the culminating point in the records of that district. Clouds of gannets darkened the immediate vicinity, or forced attention as they swooped to the surface of the water, and, rising with their captured fish, made way for others to repeat the process, in their journeys to and from "Ailsa Craig."

For the week commencing February 28th and beginning of March, or, at least, not more than five days altogether, the total catch was "32,000 baskets," and to despatch the fresh herring, 500 railway trucks were linked on to a series of special trains. This is only for one week, and brings us already into the spring fishery, although we have yet to refer to the winter fishery. More than fifty carts were employed in taking the fish to the railway stations.

Some idea of the inconveniences resulting to our fishermen through a felt want of proper harbour accommodation may be gathered from this district.

Owing to the unsuitability for fishermen landing in this harbour they land on the beach, and when a heavy surf is rolling, this is, of course, impossible. To the credit of a few gentlemen interested in the fishermen's welfare, a machine or engine was constructed by which the boats are now drawn on to the landing-stage in safety. Notwithstanding these humane agencies, loss of life and property is frequent, and at the close of this week which we have just recorded, two Ardrishaig boats, while deeply loaded and returning from the Ballantrae banks to Girvan, ran on to the "Whelk rocks," a very dangerous reef that ought to be marked by a cage-beacon; we are sorry to add that three of the crews lost their lives, and only at some risk the rest were saved.

A cruising steamer with an officer from the Fishery Board does good service here by keeping a free course on the grounds where smacks anchor and cause obstruction.

The west coast herring make splendid kippers, and the produce of this class of cured fish comes from the Stornoway district; their fishery ends in November.

Messrs. James Methven and Company, Leith, used to take the responsibility of forwarding the kippers and cured fish to foreign ports, but, finding this too heavy for them, these gentlemen were forced to charter powerful steamers for this purpose, besides an arrangement that the Baltic line of steamers shall call at Stornoway and other fishing ports on the west coast during the season, and convey the fish to Stettin, Dantzig, Konigsberg, Riga, and St. Petersburg. Besides these large steamers, smaller craft convey shipments to Glasgow, *viâ* Hamburg, and other places, and Norwegian schooners even come for this purpose. In June for the year 1882 one steamer alone shipped upwards of 21,000 barrels of cured herring for Stettin. The smaller steamers referred to bring a large percentage of the herring to Stornoway in "bulk," to be gutted and otherwise prepared for the continental markets. The last shipment, in November, from Stornoway for Baltic ports was upwards of 1500 barrels of cured herring.

As a proof how fluctuating and uncertain the fishery may be at almost any station, we may select the present district.

At Stornoway, in May (1882), we stated that some boats realized from fifty to sixty-three "crans." In the beginning of June very poor catches were recorded, though some boats were more fortunate. Again, herrings were reported to have left the Ayrshire coast for a time, as they were met in with at the sound of Killbrannan; but one month later (September) a Troon boat came into Ayr Harbour loaded to the gunwale with a take of herring. It was estimated that she had forty maise (or 20,000 herring) of medium size and quality.

Wick, once the celebrated centre for Scotland, is a peculiar example on this point. In 1794, and even within the memory of some still alive, herrings were so plentiful that the land had to be manured with them. The selling price at Bo'ness, Firth of Forth, was *6d.* per barrel.

Even a strong wind was sufficient to strew the beach with fish.

Some authorities assert that the diminution of the herring fishery is caused by the winter fishery for sprats and young herring, and that the same reason may be applied to our white fish; and the splendid fishery in the Firth of Forth, extending at one time to Kincardineshire, is cited as an instance how we can disperse the white fish by exhausting the herring shoals.

As good authorities assert that it is impossible to affect the herring, or cause any apparent diminution in the average takes for the season, as any differences may readily be accounted for by the season itself, such as stormy weather, not to mention the casualties that too frequently happen through loss of nets, boat, and even life itself. But since we have to close this order with the winter fishery, it may serve some purpose to examine the facts, and leave opinions alone in the meanwhile. The principal centres for the winter fishery on the east coast are Wick, Anstruther, and Firth of Forth. The Firth of Forth closes in January, and the other districts named begin the winter fishery in this month.

The statistical tables are the main guides in determining our question, and as these are appended in full for some years past, we may state as a broad conclusion that where a decrease is shown at one district, an increase is shown at another. For this year (1883) about eight yawls, which represented the winter fishery in Firth of Forth, reported very poor fishing indeed; but then the bulk of the Newhaven fleet were at Girvan on the west coast, or Anstruther on the east coast, and for both stations large takes and good prices are recorded. At Wick (1883) the catch was very small, and for the whole season up to March it records crans against 4693 crans of corresponding date of last year (1882). Now, although the comparison is very disparaging between this and last year, yet, since the inauguration of the winter fishery, the number for this year is, almost to a cran, "the number for any previous year."

This is very important in proving no diminution in the fishery itself, but, if possible, an increase, or the numbers of last year mean nothing, and, as we have tried to show, a decrease at one station may mean an increase at another.

We will now subjoin the tables for the district of Anstruther up to the year 1882. For this year (1883) a very promising commencement was made, and English buyers were early on the ground, and these were even more numerous than any previous year, representing London, Filey, Wolverhampton, Birmingham, Lowestoft, North Shields, Scarborough, Bridlington Quay, &c., and three of the principal English railway companies had representatives at Anstruther.

For the week ending January 27th the returns read

Monday	40 crans,	price 52*s*. to 80*s*. per cran.
Tuesday	200 ,,	,, 50*s*. ,, 53*s*. ,,
Wednesday	150 ,,	,, 56*s*. ,,
Thursday (Stormy).		
Friday	102 ,,	,, 57*s*. ,, 60*s*. ,,
Saturday (Stormy) . .	2½ ,,	,, 60*s*.

A mixed fleet of 185 boats was by the 17th of February reduced to 130, and these landed 1050 crans, realizing a sum of £3000. One boat had nearly fifty crans, and received for its cargo £130.

The 24th of February was the practical close of this fishery, owing to general stormy weather, but the details were very satisfactory for that week, and may be stated in sequence.

Monday	81 boats	400 crans, highest price	52*s.*
Tuesday	194 „	1,288 „ „	37*s.* 6*d.*
Wednesday	100 „	400 „ „	38*s.*
Thursday	160 „	500 „ „	33*s.*
Friday	91 „	120 „ „	45*s.*
Saturday	24 „	6 „ „	92*s.*
Total catch for the week		2,714	

Total catch for the season, 8866 crans, or about 1650 crans above the quantity landed at the corresponding date of last year.

Now this is very satisfactory, and reads all the more favourably when stormy weather is taken into account.

CLOSE of the HERRING FISHING at ANSTRUTHER, May 1882, and COMPARATIVE TABLES for the SAME DISTRICT.

	Crans.		Crans.
1873	9,800	1878	10,500
1874	20,000	1879	2,160
1875	8,700	1880	8,630
1876	5,640	1881	16,950
1877	2,500	1882	13,380

There were nearly 1500 boats at this district in 1882, and, in consequence of competition among English buyers, the prices averaged 41*s.* per cran. The inshore grounds are proving more remunerative than on former occasions, and the quality superior.

Taking the winter fishery as a whole, in the upper parts of the Firth of Forth and northern districts they are very good, except for this year (1883) at Wick, which is the worst season they have yet dealt with.

The take of sprats from Firth of Forth in 1881 amounted to 13,110 crans, valued at £2786; in 1880 the take was 14,500 crans, and only realised £2175.

The chief centre for the sprat or Garvie fishery is in the Beauly Firth, and extremely heavy catches were taken in

November, 1882, as some boats had 25 crans, averaging £80 to each boat, and, as near as possible, for the whole season, £4500.

Such figures may prove very tantalising to those persons who hold that the sprat is really a herring, and, either way granted, it forms a very important item in our winter herring fishery.

Total Catch of Herring over the entire East Coast of Scotland for Twenty-six Years; Lewis and Barra Early Fishing included.

	Crans.		Crans.
1857	329,251	1870	596,421
1858	393,035	1871	562,865
1859	302,943	1872	562,737
1860	463,100	1873	714,717*
1861	485,645	1874	720,964*
1862	520,280	1875	655,606
1863	439,210	1876	406,440
1864	432,064	1877	561,439
1865	395,157	1878	618,597
1866	413,065	1879	516,406
1867	474,098	1880	930,307*
1868	366,068	1881	675,107
1869	403,633	1882	730,723*

Table showing Quantites Branded in Wick during the last Twenty-Six Years up to 30th September in each year.

Years.	Quantity Branded.	Years.	Quantity Branded.
1857	48,612	1870	38,700
1858	54,348	1871	45,700
1859	50,256	1872	42,000
1860	60,559	1873	55,000
1861	67,949	1874	51,500
1862	77,564	1875	54,000
1863	80,000	1876	36,500
1864	67,000	1877	31,600
1865	57,000	1878	60,000
1866	56,700	1879	53,450
1867	66,450	1880	77,108
1868	21,200	1881	43,046
1869	63,000	1882	48,280

WICK CUSTOM HOUSE EXPORTS for PAST TEN YEARS.

Quantity of Herring entered at Wick Custom House for Exportation for the past Five Years, from 1st August to 21st October in 1878, to 7th November in 1879, to 14th October in 1880, to 15th October in 1881, and to 31st October in 1882.

Continental Ports.	This series dates from 1st August to 1st October in each Year.					From 1st August to 21st October in 1878, &c., ending 1882.				
	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
Konigsberg	9,508	4,277	2,883	882	3,223	2,315	1,950	8,450	3,144	4,667
Dantzic	19,318	22,160	12,907	7,656	6,910	20,024	12,822	40,134	23,545	22,923
Stettin	20,492	26,130	28,630	27,466	24,063	34,122	42,427	26,606	19,232	27,854
Elsinore	3,384	1,125	..	..	..	..	..	..	..	..
Harburg	9,597	2,561	1,096	8,720	3,480	1,091	3,059	2,857	1,991	..
Rotterdam	5,493	..	..	..	..	..	..	..	..	..
Memel	900	..	..	..	347	600	954	331	..	..
Hamburg	2,915	3,997	11,314	13,898	11,230	12,229	18,982	13,425	22,704	9,606
Copenhagen	..	..	..	..	..	..	..	..	..	..
Altona	..	1,240	..	692	..	..	1,754	..	941	..
St. Petersburg	1,380	..	..	1,542	..	2,039	..	..	..	1,503
Bremen	..	..	..	..	..	410	..	..	..	..
Bremerhaven	1,150	808	..	818	600	..	..	..	..	..
Geestemunde	714	802	..	..	..	..	..	..	..	..
Libau	..	..	1,000	..	..	..	..	1,316	..	..
Emden	..	..	..	..	..	..	..	..	..	..
Odessa	..	..	..	..	..	..	..	..	..	..
Ghent	..	..	498	..	..	..	..	..	..	..
Pernaw	..	..	..	..	..	..	..	638	..	..

The above dates also apply to Irish Ports, English and Scotch Ports, for which see tables annexed.

N.B.—The above tables include the exports from Lybster and Helmsdale.

ENGLISH, SCOTCH, and IRISH PORTS ENTERED at WICK CUSTOM HOUSE.

	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
IRISH PORTS.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
Limerick	..	1,430	500	850	600	1,132	..	..	100	..
Cork	162	2,176	2,325	3,140	1,520	1,590	1,425	3,085	2,110	5,870
Waterford	..	..	..	..	..	..	..	..	..	..
Dublin	..	80	1,390	2,009	..	..	240	400	850	326
Larne	..	..	..	..	..	..	..	400	..	..
Drogheda	..	..	..	..	..	..	..	450	..	..
Dundalk	450	761	1,619	..	..	..	..	..	..	..
Belfast	630	1,650	2,809	2,500	950	1,380	600	1,150	1,510	1,124
Londonderry	844	650	840	1,950	580	740	100	..	..	..
Sligo	..	880	1,210	267	..	550	..	390	552	350
Galway	..	200	439	..	..	..	..	700	450	1,378
Newry	..	340	863	..	..	..	..	650	..	..
ENGLISH AND SCOTCH PORTS.										
Annan	..	..	..	..	..	..	..	..	..	..
Inverness	..	..	..	..	..	180	..	..	..	70
Stornoway	..	..	..	..	..	..	..	..	..	60
Leith	208	224	83	260	..	296	360	..	..	..
Lossiemouth	..	..	..	..	..	..	..	..	..	..
Orkney	..	..	..	..	..	..	90	..	..	..
Stromness	..	..	..	..	..	..	..	..	..	60
Kirkwell	..	..	..	..	..	..	..	315	..	..
Burntisland	..	..	..	..	..	..	..	..	..	..
Perth	..	570	355	290	..	..	..	..	..	..
Portmahomack	50	90	..	..	..	..	..	..	..	..
Tain	..	..	..	..	75	180	..	..	..	..

TOTAL CATCH at EACH STATION from NORTHUMBERLAND to SHETLAND DURING the PAST TEN YEARS.

Stations.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
Wick to Keiss	76,601	67,450	73,186	66,030	48,243	84,248	63,094	113,186	55,542	69,926
Lybster and Clyth . . .	18,400	12,749	11,079	11,624	7,778	6,910	9,240	12,371	15,231	1,626
Forse and Forse Station .	2,250	1,673	1,574	1,820	769	282	620	592	219	28
Lathernonwheel . . .	1,965	1,045	1,468	1,785	894	512	790	637	1,237	78
Dunbeath	4,462	2,346	2,100	3,720	1,980	1,502	2,800	1,056	1,802	504
Helmsdale	5,400	5,943	3,380	8,450	13,875	7,600	10,855	10,285	13,783	3,920
Cromarty	2,751	2,400	1,551	1,166	680	..	..	..	..	..
Portmahomack	..	..	..	..	..	858	1,391	1,790	1,515	1,376
Burghead and Hopeman .	2,170	2,288	2,740	3,292	2,656	1,122	3,009	5,200	3,090	2,328
Lossiemouth.	3,060	1,900	2,880	1,456	2,277	819	4,896	7,600	3,800	2,544
Buckie District	3,179	6,370	8,140	2,775	1,760	2,864	3,832	12,413	7,173	7,630
Portsoy Station	4,032	5,240	5,832	1,550	3,767	4,935	4,670	6,950	5,600	4,650
Whitehills	2,484	2,860	1,824	900	550	1,102	1,610	1,667	840	1,174
Macduff	11,360	15,860	11,360	2,208	3,840	4,756	7,384	8,530	5,538	9,762
Banff	..	1,520	3,026	1,014	810	250	1,360	1,913	1,606	3,030
Gardenstown	12,200	8,850	8,400	2,680	5,874	4,058	7,007	6,915	7,685	4,387
Fraserburgh and District .	157,415	181,060	196,838	87,776	150,280	175,820	105,037	218,504	132,613	139,500
Peterhead District . . .	168,000	164,294	128,556	72,045	85,440	122,456	83,200	177,300	124,800	124,185
Aberdeen	60,690	64,900	61,104	57,149	77,000	69,231	36,400	78,810	78,657	80,253
Montrose District . . .	37,945	38,135	30,017	25,327	38,925	26,758	30,048	54,091	45,352	28,820
Anstruther and District .	4,305	1,930	300	110	3,005	3,975	6,490	7,840	3,660	3,145
Eyemouth " " .	31,228	24,900	29,200	15,600	11,250	25,407	52,149	48,715	59,486	59,825
Dunbar*	1,170	4,968	1,155	620	800	1,500	5,460	4,600	4,110	2,722
North Sunderland . . .	12,250	23,904	15,000	15,000	10,850	..	..	..	..	..
Orkney	19,950	20,389	12,196	4,843	9,776	14,722	8,364	16,142	14,418	16,160
Shetland	..	..	..	..	..	6,240	6,700	38,700	46,250	102,000
Lewis and Barra . . .	73,450	57,100	39,900	12,700	74,240	50,670	60,000	94,500	41,100	45,240

N.B.—Stonehaven has been disjoined from the Montrose district and become a separate station. The results for the year 1882 are therefore given separately.

* Leith added to Dunbar in 1878.

The herring is a very voracious feeder, and, according to M. Mobins, the principal food of those found in the Baltic and German Ocean consists of some kinds of minute crustaceans of the order of *Copepoda.*

In February, 1872, a number of herrings were caught in Kiel Bay at about 240,000 herrings daily for three weeks, and in almost every one that M. Mobins opened, the stomach was found loaded with *Copepoda* belonging almost entirely to one species (*Temora longicornis*). By careful counting the number present in one case was found to be 60,895, and another herring contained 19,170. The upper surface of the water swarmed with these animalculæ, and could easily have been taken with fine nets in literal thousands. A very low estimate was assumed from these facts, namely, that allowing each of the 240,000 herrings to have devoured daily 10,000 *Copepoda*, this would give for one day a consumption of 2400 millions, and in three weeks 43,000 millions.

The roe of an ordinary sized herring is allowed to contain about 33,000 eggs, and the time taken for hatching the eggs depends both upon the season and the temperature of the water. Hatching operations seldom take longer than one month, and the young fry are invariably produced from the eggs in three weeks' time.

As with all our marine fish, temperature has a very important function in the growth and development of each species, and observation is showing a close relation between large or small catches and varying temperatures. Thus a low temperature is conducive to large catches, and a high temperature to small ones, and if the thermometer registers the sea temperature to be at or about 55·5°, average catches may be expected, other things being equal.

One of the most serious allegations against trawlers is, that they both disturb and destroy immense quantities of herring spawn, and a very recent instance was cited by the Cockenzie fishermen and laid for redress before the Lord Advocate at Edinburgh, urging him to draw attention to this and other grievances they have to suffer. This is a public question, and may be dealt with at some length. The allegation was that a trawler brought up an immense quantity of herring spawn, and that it was sold for "manure." This is an old story, for the same complaints were made against the English trawlers, and at a commission of inquiry appointed by Government, it was alleged by a South Shields fisherman that he had drawn up himself three and a half tons of fish-spawn, and further, that he has seen a ton and a half of herring spawn offered for manuring purposes.

It is important to remember that up to the present date there is no diminution, but, as we think, rather an increase in the herring fishery; for all that it behoves us, for the future interest of our sea wealth, to make the strictest inquiries from competent sources and legislate accordingly. More than fifty tons of herring have been taken at one haul, and, considering the constant drain at all times of the year by the varied enemies of the herring, there is reason enough to feel anxious about the future welfare of our herring fishery.

The report of the Fishery Commissioners issued in 1879, estimates that 120,000,000,000 of herrings are annually destroyed by men, birds and fishes around the British coast, but that 1,200,000,000,000 eggs are deposited in the sea as a balance against this draught.

It is a fact that fifty years ago large quantities of fine herring could be found as far up the Firth of Forth as Alloa, and the curing troughs still remain along the coast as a sad evidence; but it could not have been the trawlers who prevented herring ascending the Forth, seeing that they are a recent innovation on the east coast fishery for Scotland, and it is interesting to find that the Newhaven fishermen have launched a trawler for themselves, as of all, perhaps, they had most reason to complain. That the trawl will bring up herring spawn there can be no doubt, but, as a rule, it cannot do so, for herring prefer spawning among rocks or upon coarse ground, where the trawl cannot go without injuring itself.

Again, trawlers assert that our flat fishes are the most voracious feeders upon herring spawn, and that, as they capture a large proportion of these fish, they are really conferring a benefit upon our fishermen by its use.

A counter allegation was, that the use of circle trawls instead of ordinary beam-trawls in the sprat fishery enabled the fishers to capture young herring, and that the destruction of these young fry was fatal to the white fish fisheries and conducive to a diminution of the herring themselves.

A very important point comes out in connection with the Firth of Forth, and one which we have already alluded to, namely, that herring became scarce in this district before the introduction of trawlers. If it can be shown that there is no decrease on other parts of our coast where trawling operations are carried out, then the question is so far satisfactorily settled, and we think the statistics are on this side. But there are some very important reasons why specified limits as to the kind of trawl to be used, and the place or grounds to be fished over should be rigidly maintained. The law at present seems to be a dead letter in many points, and this is chiefly owing to a felt want for marine police. It is a frequent occurrence for trawlers to run right through the nets, and it is at any time dangerous for them to be in the vicinity of open boats using either nets or lines.

Trawling cannot be abolished without an international convention, nor is it generally desired that it should be even without this; but that some effective measures which will meet all cases is requisite, and urgently demanded, the baneful system of coopering alone will show. A cooper is a floating public-house, under the colour of a fishing smack. The worst is that these bumboats sell or barter poisoned drink in return for fish; and cruel evidence has been proved against this villainous traffic, where in many cases not only do they take all the money first, but have as often succeeded in securing fish, nets, gearage, and even the boats too, in return for a maddening drink that has made some victims leap overboard through its effects. Evidence of a worse nature than this was brought against foreign fishermen, chiefly Belgian and Dutch trawlers, to the effect that not only were the nets purposely run through, but the warp was cut in a deliberate manner by an instrument called the "devil." This instrument resembles the end of a huge scythe, and when fixed at the stern of the ship it can be used with terrible effects to the helpless fishermen.

International protection is both needed and asked for as a guarantee against these nefarious proceedings, for the regulations at present existing only apply to territorial waters, and the application of the law is the fault at issue. Even where ordinary grievances prevail fishermen can raise an action for damages, but as a rule they have neither opportunity nor means to do so. Some useful remedies have been often suggested, such as empowering our coastguardsmen at their respective stations to act on the complaint of a fishing crew, or to have at least four swift cruisers in the German Ocean, representing England, France, Belgium, and Holland. Also, with a proposal to adopt fish culture in some of our favourite estuaries and firths, that trawling be entirely abolished from such districts, &c.

It is now five hundred years since a petition was presented to the English Parliament against the use of a machine which not only retained all kinds of fish, both small and great, in the meshes of its net, but also by its iron supports destroyed fish, spawn, &c., "to the great damage of the whole commons of the kingdom." Trawling, then, has not yet reduced the fish supply, and it only now remains to guard against this.

Much of the so-called herring spawn has been proved to be gelatinous bodies of marine zoophytes and ascidians, or the spawn of cuttle-fishes, but, as we stated, herring eggs have been brought up by the trawl.

The old legal mesh for the herring net was 1 inch square from knot to knot, but since 1868 fishermen have been allowed to use any size of mesh they please. It is desirable that the old law of 1809 be re-enacted, because a small mesh will catch small, and therefore young, herrings; at the same time it can only choke large herrings without catching them. There are very many points which require overhauling in the interests of the fishermen alone. And there are some which require redress in the interests of the public. For instance, boat owners and others "sailing by the share" must proceed in the first instance to a custom-house, and sign their respective contracts before the officials. The charges for taking depositions as to damage or loss at sea should be from some other source than the sufferers themselves.

Great damage is done to nettage by lost anchors ripping them open, and these hidden snares are unintentionally encouraged by the Board of Trade, for heavy penalties bind the salvors to deliver "swiped anchors" to the Receiver of Wreck. Now, as very few owners return to look for lost anchors, and the amount given by the Board of Trade for salvage is extremely small, it follows that very few take the trouble to clear the grounds, notwithstanding the general loss continually accruing.

Again, if statistics are to be taken at all, they should be dealt with generally all round the coast, either in the order of the fisheries themselves, or commencing in the north and ending in the south, or where practicable. Statistics for the east coast of England are always awanting, and when given very unreliable as a total estimate to the growing importance of the English coast fishery.

The spring herring fishery at Lowestoft is a recent addition to this industry, but usually the largest deliveries of the season are landed at Yarmouth. It is asserted that in 1853 upwards of 10,000 lasts of herrings were cured at Great Yarmouth. And it is within the estimate to allow the yearly average to be 15,000 lasts delivered at Great Yarmouth alone for the past thirty years. One authority assumes the grand total for the past thirteen years to be at least not less than 2,772,000,000 herrings, or 210,000 lasts.

Before noticing the leading fishery and particular features connected with it, a novel and very pleasant pastime is offered to anglers through the open facilities in catching herrings. A few enterprising individuals have even supplied the markets by angling operations over the side of a boat, and others have taken them from the shore itself. The reason why this mode of fishing is not more general than it deserves to be, is the erroneous ideas existing about the fishing apparatus and habits of the herring. Herrings are a surface-swimming fish, and the great point to successful angling is the smallness and brightness of the hooks used, as the herring possesses a very small mouth. In the north of Scotland some anglers fix the hooks from the end of ordinary stocking wires, and these wires are about twelve inches distant from each other on the line. No bait is required, but the hook must be small and bright.

PART III.

THE LEADING HERRING FISHERY OF THE WORLD.

As the herring fisheries of Scotland are the leading fisheries in the world, we may infer from this fact alone that there must be gigantic modes of carrying on the business in the mighty waters.

The curers are the real promoters of this industry; in some cases they even provide the boats and gearage; but arrangements are made long before the season begins, notwithstanding the fact that the fishery is to a large extent uncontrollable by regulations. Thus, though boat-owners may bind themselves to deliver a certain number of crans at a given time in the season, it is after all a probability that these very men may have the "cleanest" boats for that season.

The "bounty system" is a mode of advancing money, and as often a question of retaining it, and cannot be compared to the "share" principle, where the fishermen have a better compensation for their arduous work. Boat-owners try to strike as good terms as possible, and by stating an agreement entered into last January (1883) for the ensuing season, we may illustrate this.

Herring Fishing Engagements at Broughty Ferry, January, 1883.

Twenty-one boats, with the crews already made up, are arranged to fish as follows:—Montrose district, ten boats; Aberdeen district, nine boats: the other two to fish between or on the coast bounded by the Tay and Montrose. Terms, £45 of bounty, £1 per cran of fresh fish for a complement of 200 crans, and 15*s.* per cran for salted herrings. Arles, money or perquisites in addition to each boat's crew, £2. In the case of the Montrose boats the herrings will only be considered fresh when landed at 1 A.M. In the case of the Aberdeen boats the herring will only be considered fresh when landed at "midnight." After these hours the prices allowed will be the same as is allowed for salted fish, &c.*

The highest prices are paid for the early takes in every district; and as it would be noticed, the men are bound down to a given time, even should their boats be so loaded that they cannot get in.

Enormous quantities of early fresh fish are trucked immediately to English markets, or partially cured and shipped to German ports, till at length the curing yards become a scene of life and activity that can only be compared to the herrings themselves in their onward progress beneath the waves.

The largest quantity exported from any Scotch port as a cargo was that of last season (1882) by the ss. *Silesia*, from Peterhead, with 3075 barrels of cured herrings, and at present Peterhead and Fraserburgh are the leading centres of the east coast for Scotland, just as Great Yarmouth and Lowestoft are in England.

For Fraserburgh the season's cure of 1882 is very close on the numbers of 1881, but both the vessels employed and the exportations show an increase, thus—1881, vessels employed, 158; 1882, vessels employed, 173. Or to tabulate it in fuller form, thus :—

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* It may be stated that the bounty is better this year by about £10 than on any previous occasion.

Fraserburgh.		**Fraserburgh.**	
Season 1882.		**Season 1881.**	
Vessels employed for conveying cured herring to continental ports—		Vessels employed in 1881—	
Total number	173	Total number	158
Barrels exported . . .	160,678	Barrels exported . . .	145,494
	Barrels.		Barrels.
July	28,914½	July	29,845½
August	63,574½	August	39,297
September	47,321	September	40,053
October	20,131	October	22,800
November	..	November	12,496
December	..	December	620½
January	736½	January	..
February	..	February	382
Totals . .	160,677½	Totals . .	145,494

The second section of tables gives a comparative view of the Monthly Shipments under their respective dates to various continental ports.

The curing process begins at once, and for this purpose all hands are ready to begin work. The herrings are counted out by the cran to the curer; the cran is a measure holding forty-five gallons. The "gutters" or eviscerators immediately commence to open and clear away the intestines. These persons are usually women, who work in gangs of five or eight at a time. The fish are carried to the "rousing troughs," where, as the name implies, they are roused in salt, and so expert are the women at cleaning, salting, and packing, that they will produce a barrel to the cooper in ten minutes with ease.

When large takes of herrings come in it is necessary to have many hands at work, for, unless the herrings be in pickle the same day of arrival, the officer will not brand them, or at least is supposed to see that this requirement is fulfilled.

This brand question has been a bone of contention and source of controversy for many years, and it is unfortunately branded itself by many fishermen and large curing-firms as a useless and misleading system, and the question has now come to be whether it should be retained or dispensed with. The old Scotch Fishery Board was established in 1808, but it seems probable that this vexed question may be successfully handled by the re-arrangements of the Fishery Board of 1882. As the case stands, the duties of the Board are the branding of the herrings according to quality, together with a collection of statistics as to the fishery itself.

Many of the firms who stand upon the merits of their own productions have a strong case in point of various classes of cured fish, which at the same time would not be unimpaired by a British brand, and, to say the least, would look all the better.

The Stettin Herring Report for last season, dated November, states that the supplies of Scotch herring brings the import up to "85,553 barrels crownfulls, against 87,238 barrels in 1881; 48,751 barrels unbranded fulls against 32,377; 46,112 barrels crown matties against 50,902; 42,213 barrels unbranded matties against 30,829; 7802 barrels crown and unbranded mixed against 5921, and 12,482 barrels crown and unbranded spents against 13,279; 3656 turnbellies in barrels against 2,919—246,559 barrels in all, against 223,465 barrels in 1881.

"This year's import is now considerably larger than the total of last year, and will be still increased by about

10,000 barrels floating for our port; but the stocks of Scotch herrings are not all large here, in fact, considerably smaller than last season, the consumption having been very satisfactory."

The herring is known as fry or sil, matties, fulls or full-herring, and spents or shotten herring.

The matties are the finest condition of the fish, when all the food goes to form the fattening properties of the fish. A full herring is a later stage with the milt or roe fully developed, which is not the case with matties; and, as the name implies, a spent or shotten herring is one that has spawned.

The herring is a very symmetrical fish, and its distinguishing features are the head and the belly. Although there are no eyelids, yet the eyes are large and extremely beautiful. It possesses all the characteristics applying to such fish as were enjoined as edible food in the Scriptures. It has seven fins, and the number seven is the perfect number in Scripture, and these fins are respectively—dorsal, 1; pectoral, 2; ventral, 2; anal, 1; and caudal, 1.

Strange markings may be seen beneath the delicate scales, which are compared by fishermen to a herring-net; indeed, some assert that the idea was conceived from this as to how a net should be constructed; fancy might rather attribute this to the first herrings which escaped from the nets, and the impressions they received would be indented in their whole being, and handed down to future generations. And when the mouth closes, so as to allow the cheeks to overlap the lower jaw, certain well-defined outlines are seen on each side, which fishermen say resemble a fishing-boat with the mast in the very position it should be when the men are engaged in fishing operations. The air-bladder is joined both to the vent and stomach. The vertebral column has fifty-six bones. The ribs consist of twenty-one to each side. The head is furnished with twenty-eight bones, eight of which form supports to the gills. From end to end the entire skeleton numbers three hundred and seventy-one bones, and in this form it presents a marvellous view of constructive skill and adaptation to its home in the great deep, and reflecting the mind at once to that supreme source from which order has sprung.

The order of the fisheries just given will indicate the habitat of the herring, and it is never found in warm latitudes, though often found both in and without the Arctic circle. Small varieties are met with on the northern shores of Greenland, and it is scarcely necessary to state that the annual migration of herring shoals to and from polar regions is now known to be a fallacy. It is found in the North Atlantic Ocean between forty and seventy degrees of latitude, and abounds in the northern seas, and found in greatest numbers on the British coasts.

The herring is not so prolific in the produce of spawn as many of the other species are, unless we take into account that it may spawn oftener than other fishes; and this is a point that many able men are still investigating. It is estimated that if the full-roed herrings recorded as taken for the year 1881 had been allowed to spawn, and if that spawn had become fry, then "there would have been produced no less than 6,946,470,000 barrels of herring," had such been caught. This assumption is very modest, and, of course, is going on the old lines that the said full-roed fish would only spawn once, though they spawn at least twice in the year; and it seems certain that they spawn much oftener, as both "spent" and full herrings are caught in nearly any season and at any place. The fact really seems to be that, once they come to maturity, it is only a question of regaining their strength after spawning as to when they shall spawn again; and it is not improbable that the fecundity of the herring is much greater than it is commonly supposed. When accurate knowledge is established on such important points as these, then our dominion over the fish of the sea will have attained its highest degree, "for knowledge is power." There is also good reason for believing that what is generally called a white sea by fishermen is really produced by the innumerable presence of herring spawn and herring fry, as such are actually found upon the surface of the waters in thousands, and many think, despite the fact that herring eggs are found at the bottom of the waters, that they are really produced and vivified at the surface. Indeed, some fishermen think that it is owing to the non-impregnation of milt and roe that eggs are found at the bottom at all, and that only those eggs float which have been so impregnated; if so, this places the herring on the same footing with our other white fish in regard to its breeding points.

The report of the Fishery Commissioners for 1878 states that 2,400,000,000 of herrings are annually caught in the North Sea by the British, French, Dutch, and Norwegian fishermen, and it is estimated that Scotland alone possesses no fewer than 14,500 herring-boats, with a total for men and boys of about, or more than 50,000, and statistics show that these numbers are increasing every year as yet.

Surface fishing is an improvement on the old method, and proves that the herring are nearer the surface of the water than was usually supposed. This method is conducted with great success, and consists in letting the back ropes be lowermost, so that the bottom of nettage may float towards the surface; but this plan is open to great risk from passing vessels.

Experienced fishermen are usually able to shoot their "nets" at the right time and place, and they can even sight and fix the spot for operations at a distance, as the schools of herring will often throw an oily phosphorescent gleam along the surface of the water. There are other indications as to the presence of herring, and often enough the nets are shot at a venture. Some Norwegian fishermen use water-glasses in their coast fisheries; this is a simple instrument that enables them to see a long way into the depths, and is probably only a practical aid at such places as the fjords or inshore fisheries. When the train of nets has been cast into the sea by being paid over the stern of the boat as "she" is rowed slowly from the starting-point, then a great perforated wall is left in an upright position on which the shoals will strike in their onward progress, and thus be taken prisoners.

The beautiful tinted silver rays produced as the herrings are emptied into the boats baffles all description, but the curing-yards are now the only thoughts for the fishermen with their silver treasures, for this may be the last haul for the season, and, as we have been there already, we may now take leave of the "Herring Fisheries," and, as we say good-bye, we wonderingly inquire, if all the herring-nets in the world were joined together, where would they reach?

"WHO CAN TELL?"

THE HERRING FISHERIES.

"Not enjoyment and not sorrow
Is our destined end or way;
But to act, that each to-morrow
Find us farther than to-day."

H. J. GREEN.

THE HERRING FISHERIES.

THE increasing interest shown year after year in all matters connected with our fisheries is a sign of the times that can neither be overlooked nor under-valued. It is practically a recantation of the doctrine that the subject was one merely concerning professors and students of natural history, and an acknowledgment that, considered with reference to British industry and commerce, it is a matter of paramount importance. One of the most interesting divisions of the fisheries is the herring fishery. It is interesting, not only on account of the large number of persons which it employs, and its influence on the country financially, but on account of the natural history of the herring, of the theories which have been advanced and overthrown respecting its migration, and of the veil of mystery which for a long time hid the secret of its reproduction from human understanding. It is obvious that whatever tends to elucidate and clear up disputed points in its natural history must react in a beneficial manner commercially. The record of the last few years has been far from being a blank page in this respect; but perhaps, for the sake of completeness, it will be well to state a few of the earlier facts ascertained of the natural history of the herring.

Let us consider first, then, the senses of the herring. They have been the subject of much difference of opinion, as indeed they have been concerning all fish. Yet the organs, though of course very minute, are so distinctly formed that we cannot avoid coming to the conclusion that they were meant to be used. The tongue, for instance, is very small, but there is no doubt about a tongue being there; and what is a tongue there for if not to be used? It is true that the senses of taste and smell of some of our fish are not always very correct, especially of those who prefer the neighbourhood of sewers and drains; but they are the exceptions which prove the rule. Then, as regards hearing, the balance of evidence seems to be in favour of their being endowed with that sense. We need not question whether they are able to see or not.

One of the most important points to be ascertained with certainty is—what constitutes the chief food of the herring? There has been much diversity of opinion on this matter; but it appears to be pretty clear that the herring does not feed upon one kind of food. The preference seems to be for small crustacea, although worms and the eggs of fishes have been found in their stomachs, and even young herrings. It will thus be seen that the cultivation of crustacea has a very important bearing on the prosperity of the fisheries; for we cannot hope to bring the latter to a high degree of efficiency if the food supply is not promoted in a corresponding degree. It is a noticeable fact that herrings caught in lochs and bays are superior in quality to those caught on the open sea-coast. What is the reason of this? Is it that the food is more abundant or more suitable? It is a point worth investigation.

The next important point to be solved is the settlement the period of the year when they spawn. On the satisfactory solution of this problem the very existence of the fishery greatly depends. If we do not know when to look for the fish, we cannot catch them; therefore anything that adds to our knowledge on this point is a very material assistance. A great many of our eminent men are of opinion that the herring spawns twice a year. We know, however, for certain that herrings appear at different times at different places; and the investigations of the last few years have led us to believe that the object of their appearance off the coasts is for the operation of spawning. For instance, at Wick they appear between July and September; at Eyemouth between June and September; at Arran between July and November; and at Thurso as early as May. In the Moray Firth the time is from June to September, but in the Firth of Forth it is from November to March. [It may be noted incidentally that the Scotch fishery of last year was very successful.] In England we find the herrings at Yarmouth between June and November, off Cornwall in August and September, off Kent in October and November, and off Yorkshire between July and September. In Ireland they are fished at Galway in September; off Kerry between January and March; and in the Irish Channel between June and November. Taken as a general rule, we may say that the winter herring generally spawns in February and March, and the summer—or autumn?—herring in September and October.

It is an easy transition from the subject of their spawning time to the subject of their migration, or supposed migration. There was a time—and we should not have to go back very far—when the theory of their migration from the Arctic regions was most stoutly maintained. We know better now. The interesting story was to the effect that the normal abode of the herrings was in the Arctic seas, and that they made periodical visits to the south (led by an advanced guard of one or two fishes!) for the purpose of spawning. Little was wanting to complete this dramatic story. We knew that the herrings usually lived in the North; we knew that they sometimes came to the south; we knew that they divided off the north of Scotland, one corps going to the right and the other to the left,—all that was wanted were the herrings themselves. There is not, however, a shadow of a doubt about our previous belief being a huge mistake. The herring inhabits the deep water round our coasts all the year round, and comes periodically towards the shore to propagate its kind. The chief argument that has been set up in favour of this statement is, that year after year, and at the same time of the year, we always find the same kind of herring in the same place. It is therefore a very reasonable assumption that they are in the neighbourhood all the year round. Besides, herrings caught in the extreme north of Scotland are inferior and lean compared to those caught at the same time farther south, which should not be the condition of herrings that are just about to spawn. Whether there are any who still believe in the migration of the herrings from the Polar regions—and we would remind them that they must also believe in the advanced guard story, too—matters little; it is enough that a very large number of persons have long since abandoned it and accepted the other theory.

The next point on which we would willingly have more information is—what period elapses between the time of depositing the spawn and the appearance of the young fish?

This is a matter very difficult to ascertain, chiefly from the difficulty experienced in observing the operation; but we may take it that the eggs are converted into fish in a fortnight or three weeks. In about nine weeks' time the fish are 3 or 4 inches long, and are full-grown herrings in about a year and a half. Any information on the latter point would also be extremely useful. It would dissipate some doubts as to when the operation of spawning is performed for the first time by the young herring.

After all, it must be confessed with regret that our knowledge of the natural history of the herring is exceedingly limited. It has been thought that we may learn a good deal from those whose vocation it is to catch them. That, however, is very far from being the case. The ignorance among the fishermen of the habits of the herring is certainly not very flattering to our insular pride. That it betrays a want of observation on their part, or incapacity to connect their observations with their occupation, cannot be denied. Perhaps the remedy might be found in erecting schools for fisher-boys, where the young generation might learn something of elementary Natural History that might act as an incentive to further observation of animated nature. The aim of all knowledge should be to apply it to the affairs of our every-day life.

A study of the fisheries of other countries is always interesting, and often instructive. We may in this way often learn methods of capture and curing, that may be profitably followed by ourselves; and we may also gather fresh facts concerning the natural history of the fish. It is but fitting to commence with a reference to the Dutch fisheries. We cannot help feeling a respect and admiration for a people who once possessed the finest fisheries in the world. We recall with envy the picture of their former superiority, a superiority which has long since passed away. The naturalists tell us that their superiority was owing to their fishing on our coasts in our absence on other matters. Whether that was the case or not we cannot say; but even supposing that it was, it looks as if the Dutch still deserved the palm for superior strategy. While, however, we willingly accord whatever praise is due to the Dutch, we are far from endorsing the extravagant eulogy that many have thought fit to bestow on them. The Dutch fishermen of old acquired, and for a long time maintained, their proud position by their method of curing herrings. It is somewhat strange that, great as England was in many respects at the meridian of Dutch prosperity, she should have been so far behind in this matter. Probably those great events of the time of Elizabeth were themselves the cause. The people were too much occupied by foreign affairs to attend to humbler matters at home. The Dutch fishermen kept their secrets pretty much to themselves; but it will probably be found that they owed much of their success to their curing the herrings immediately they were hauled up from the sea.

The French fishery is chiefly remarkable for the cure of sprats (about which we shall have something more to say presently) in oil.

The Norwegian fishery is noted for various methods of smoking the young herring.

A very interesting mode of fishing under difficulties is practised in Russia. Owing to the severe climate of that country, and to the consequent freezing of the water, the fishing industry is much curtailed; but the fishermen manage to secure a good many fish by making lines of holes in the ice, and inserting their nets in them.

It may not be inappropriate to say something here about the whitebait, the sprat, and the pilchard. As regards the whitebait, the question that chiefly interests us is whether it is the young of the herring or not. For a long time naturalists held that it was not; and there is a good deal that might seem to support that view. The head of the whitebait was thought to differ slightly from the head of the herring; the comparative length of the head to the rest of the body was supposed to differ, and the body itself was flatter than the herring, and lighter in colour. But there is an argument that completely over-rules and destroys these minor objections, viz. that the whitebait is never found with milt or roe. This, to our mind, taken in conjunction with the fact that large quantities are sometimes caught with herrings, demonstrates very clearly that the whitebait is the offspring of the herring. The length of the whitebait is between two and four inches, and, very rarely, five inches. It is very plentiful in the Firth of Forth, and in the Thames, and is sometimes found in the Clyde and other rivers.

The sprat is also an interesting fish. It has been accused of following the example of the whitebait; but, although it is remarkable that sprats are taken in large numbers with herrings, we will not, on our present knowledge, go so far as to say that they are the offspring of the herring. There is some relationship between the two. However, the fact of sprats having milt and roe at the proper spawning-time seems to show that they are not the young of the herring. The sprat fishery commences in November, and lasts till February or March. The principal coasts on which it is prosecuted are Norfolk, Suffolk, Essex, and Kent.

The pilchard resembles the herring in some respects, although there are important differences both in the formation and in the habits of the two. For instance, the scales of the pilchard are larger than those of the herring. Again, the pilchard will rest in a horizontal position if suspended by the dorsal fin; while the herring dips towards the head.

Further, the pilchard has an exceedingly limited distribution, while the herring has a very wide distribution. The pilchard fishery generally commences about July, and continues to December. Like the herring, the pilchard is a migratory fish, lives in the deep water, and approaches the shores to spawn. The coasts that it most frequents are those of Devon and Cornwall; in fact, we may say that the fishery is confined to those counties, and the fish appear in great numbers.

There is yet one other digression that we would make. Scotland has the honour of being the home of two very puzzling fish, namely, the powan of Loch Lomond and the vendace of Lochmaben. Careful observation has "almost persuaded" naturalists to believe these fish to be descendants of herrings; and the reason they assign for the existence of the fish in fresh water is that the monks of old, who, it is to be presumed, lived largely on fish, brought them there. The habits of the fish certainly very much resemble those of herrings.

We will now consider the question of the herring brand. A very slight examination of the subject will suffice to show that the system is opposed to the principles that should regulate trade. It is true the brand is not compulsory, which, while robbing it of many objections, really amounts to very little, because every large curer is bound to use it for the simple reason that everybody else does. The brand, however, is very useful to small curers, because it gives them a chance of competing with the large curers. But it is a distinct form of State interference—an interference in the sale of an article of extensive consumption. What are the reasons that can sanction such an arrangement? Why are not our potatoes, and cabbages, and boots, and chairs and tables branded? The chief reason that can be urged in favour of the continuance of the brand is that it is convenient for foreign trade. The brand has been in existence for so many years that the buyers in foreign countries have learnt to regard it as a guarantee that they are not being cheated. Barrels bearing the Crown brand are never waiting for a buyer, and they are passed on from hand to hand with nearly as much convenience as paper money. We cannot deny, either, that the system greatly assists the people in their purchases by the rejection of inferior fish. It is best as a rule to choose for ourselves, but there are certain occasions when the judgment of a skilled officer is preferable to our own. In the next place, those whom the question most nearly affects are in favour of the continuance of the brand. If those who are most nearly concerned are content to pay the small fee for the brand to the Scotch Fishery Board, it certainly seems unwise and unnecessary to disturb a system that has worked so well.

We have here, then, a remarkable instance of a system undoubtedly wrong in principle working well in practice. It would seem that our objects have been accomplished by means which are open to question. Nevertheless, although, in the circumstances, we would wish to see this particular system maintained, we strongly disapprove of it for other articles. No fresh system should be *started* on these principles. It may be urged that a fresh system would become as successful as this has become. We think not. This system was instituted when the fishery was comparatively undeveloped, and therefore, having grown with it, the system has become, as it were, a part of the fishery. But to start a similar system now, in connection with an article of extensive use, would be a decided mistake. We may depend upon it that the less we have of Government interference the better it will be for us. There are, of course, a few matters, such as the regulation of cab-fares, that are, for simple convenience, best done by the Government. But it is a dangerous principle. It has led to tyranny in the past, and it may lead to tyranny in the future. The times have passed—we trust for ever—when justice was openly bought and sold, and when monopolies were bartered for political objects. We cannot forget those days, never to be recalled without a feeling of shame, when one class was raised by the degradation of another. It is a dark page in our history; but it is, nevertheless, one that must be guarded against for the future. If ever the time should come when Englishmen will submit to all trade being arrested by imposts and fetters, we confess that we should have little hope for the future of England. Are we to be treated as children—as persons who are incapable of judging for themselves? No; the noblest aim of man should be to think and act for himself, to exercise the intellect with which God has endowed him above every other creature, and to contribute as far as in him lays to the sum of human happiness.

THE

SCOTCH EAST COAST, ORKNEY AND SHETLAND,
LEWIS AND BARRA

HERRING FISHING.

"*PRO BONO PUBLICO.*"—[W. S. MILN.]

THE SCOTCH EAST COAST HERRING FISHING.

FISHERMEN — NUMBERS EMPLOYED — HABITS AND SOCIAL CONDITION—QUALITIES AND CHARACTERISTICS—WEALTH.

THE number of fishermen actively employed in the herring fishings during the seasons, from Northumberland to, and including, Wick, and at Orkney and Shetland, and Lewis and Barra in the Hebrides, can be safely estimated at over 45,000 men and boys.

The habits of fishermen are distinctly discernible as pertaining to a broad sectarianism. Individually, their idea of bodily comfort consists in having on a superabundance of clothes. Even during the warm months of July and August, whilst working hard in hoisting their catch to the carts on the quay, it is ridiculous the amount of clothing they have on them. The great beads of sweat pouring down their faces and bodies, and the ofttimes visible steaming therefrom, does not convince them that they are overclad. 'Tis a pity they do not regulate their dress in accordance with the weather, as it is obvious that over-burdening one's self with clothing is unhealthy, and weakening to the body, especially during warm weather. What a contrast to the French fishermen ;—they having a tendency to underclothe themselves, judging by their open-breasted semmit, or shirt. Our fishermen are likewise very much needing a thorough lecturing and training in the art of making clean by a judicious and plentiful use of soap and water, and an occasional total immersion. The fisher-women might follow the example also with advantage. Of course there are exceptions, and they deserve commendation for their cleanliness. Their homes are comfortable, but are slightly overcrowded, generally clean, and the furniture more ancient than modern. Fish is their great sustenance, but when they are at the fishing centres the beef they then use makes up for the scarcity whilst at home during the winter. It is necessary to give a justly merited warning and particularly required denunciation regarding overcrowding at the large centres, such as Fraserburgh, Peterhead, Wick, during the season. House proprietors and lodging-house keepers are more to blame than the fishermen, as they should be made to provide suitable accommodation if they are to be allowed to lodge fishermen and their families. As for the fishermen, poor simple people, they are only too glad to secure any shelter during their temporary residence, no matter how filthy. The accommodation being limited, overcrowding is general, and the manner of their huddling together in outhouses, stores, lofts, and even worse places, is a disgrace to civilisation. To know about, and to have seen the overcrowding and filth, and to have inhaled the nauseous vapours when passing these temporary abodes, gives one the feeling that such living is not only disgusting, but degrading. Such mode of living is not the fishermen's choice, but is forced on them as a necessity. It is high time that a Parliamentary Commission be appointed to examine and report upon the accommodation available for the fisher people at the various herring fishing stations. Let their visit take place during the heat of a season, and the disclosures will show an indecency and moral degradation of a most appalling nature. One visit would certainly be sufficient, and would be the means of raising the fishing community from a backward and unwholesome living, to one more healthy and modern.

The qualities and characteristics of fishermen may also be said to be sectarian. Amongst the Highlanders intemperance is the prevailing vice, but it is gratifying to observe the wonderful alteration that is gradually making itself visible in their sect, and which augurs well for the hope that in the near future our fishermen will be known as a temperate race of men. Religion has also a considerable part of their attention. They are chiefly connected with the Gaelic Church. The southern fishermen are pretty well mixed up with all the denominations. Missionary work receives good support, is beneficial, and has a splendid ground to work upon. However, the fishermen, notwithstanding their regular church attendance and adhesiveness to their creeds—seeming equal to fanaticism—are found, on a close observation of their daily life, to be divided thus, one-third zealous, God-fearing, and good living men, while the other two-thirds are not, and a great part are (I am sorry to have to say it) in disposition inclined to the opposite direction. I draw my conclusions from close observance. Obstinacy in argument is a prominent characteristic. There is also a deep vindictiveness and revengefulness in their natures against those whom they may deem enemies. Without flattery, let us glance at the good qualities of our fishermen. To their employers they are respectful, and self-knowing, subservient; hard working and energetic in their occupation;

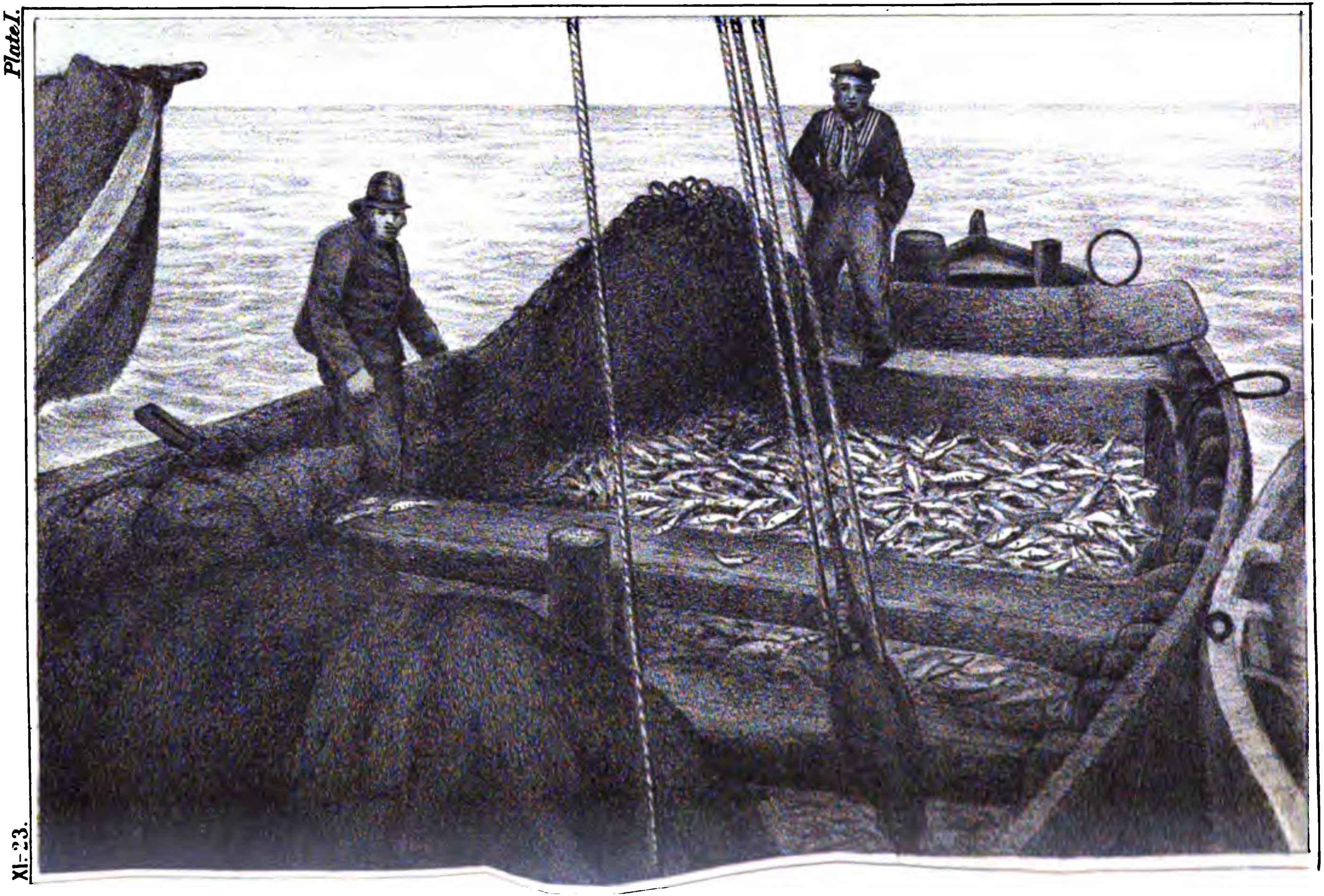
cautious (after a manner, ofttimes unnecessarily and unfittingly so); bold and daring in presence of danger; affectionate to their wives and children; ambitious to be affluent, and desirous to keep on a level with the times; but withal, retaining a strict adhesion to their caste.

Wealth is pretty equally divided. Well-to-do fishermen are sure to possess, first, a house and furniture; second, boat and gear, or perhaps shares of a large and a small boat; third, nets, lines, and other fishing materials. The heads of families are generally tolerably comfortable as regards means. A small proportion may, through unfortunate circumstances, be poor for a time, but perseverance soon overcomes the poverty. The various banks receive a goodly amount of money on deposit from them; and when we consider that mostly all the houses in the fishing villages which they inhabit belong to themselves for the greater part, we must allow that as a class they are both powerful and rich. Young fishermen, as they earn and save money, invest it in their fathers' or relatives' boats, thereby securing an interest in the boat, and therefore in the industry. They earn and save more money than any other class in Scotland, and as fortune and hard work seem to go hand in hand, the energy and instinctive ambition for supremacy entitles us to reasonably expect a continuous and progressive prosperity in the future.

FISHING MATERIAL—BOATS AND GEAR—NETS—BASKETS AND SPADES—METHOD OF CATCH—DELIVERY.

Fifteen years ago the fishing boats were principally those which we know now under the name of the "skaffie," a fast sailing, but unhandy and very much inferior boat compared with the present new style. The cost of a

Plate I.



XI-23.

"skaffie" boat would then range from £175 to £210. The "KY"—i.e. Kirkcaldy style, is the most popular at present. They are first-class built, and will carry with comfort a catch of 70 to 100 crans of herrings, equal to 8 to 15 tons. Their dimensions and "rig" make them suitable for a further from shore fishing than the "skaffie." According to the newest improvements and additional appliances, a first-class "KY" style of boat would cost over £300. There have been a good many highly superior boats launched during the past two or three years, their shape slightly differing from the "KY" style, but they are materially of the same class, with the exception that they are better deck-built and have the most modern appliances. They cost £20 to £50 more than the average "KY." Gear comprises sails, ropes, anchors, chains, oars, &c., and their cost is included in the price of the boat. The following table shows the exact number of boats fishing at each station, from Northumberland to Shetland, and including Lewis and Barra, for the past five years.

Stations and Districts.	1878.	1879.	1880.	1881.	1882.
WICK to Keiss	579	597	655	570	600
Lybster and Clyth	131	132	141	147	140
Forse Station.	14	10	9	4	4
Latheronwheel Station . . .	16	15	15	15	13
Dunbeath Station	39	40	32	34	31
Helmsdale Station	160	130	170	145	160
Portmahomack Station . . .	26	16	22	28	30
Burghead and Hopeman Station	34	17	47	45	50
Lossiemouth Station	13	24	42	47	42
Buckie District	32	26	75	67	95
Portsoy Station	35	38	39	40	46
Whitehills Station	9	13	10	10	12

Stations and Districts.	1878.	1879.	1880.	1881.	1882.
Banff Station	2	9	8	11	15
Macduff Station	36	52	41	39	66
Gardenstown Station	25	49	36	53	41
Fraserburgh District	879	1006	944	1007	900
Peterhead District	683	768	716	849	822
Aberdeen District	490	400	361	501	482
Stonehaven District	..	..	..	..	101
Montrose District	233	204	244	225	166
Anstruther District	35	36	70	36	20
Leith to Dunbar	40	65	60	60	45
Eyemouth District	321	233	373	282	381
Orkney Islands	192	183	170	180	197
Shetland Islands	120	206	206	284	372
Lewis and Barra	871	1084	1381	1285	1300

Taking the year 1882, we have 6131 boats, which, calculated at an average cost of £275 per boat including gear, gives the handsome capital of £1,686,025 sterling invested solely by fishermen in these herring boats, altogether exclusive of nets. It is pleasing to relate that these boats are being covered against loss by Insurance.

There is now no regulation size of mesh or net. The net as bought from the manufacturer is 60 yards in length, but when hung on the back rope is only equal to 40 yards long. The depth is on average about 12 yards. The cotton threads comprising the net are of 9, 12, 15, 18, and 21 ply. The mesh is about 1 square inch, measured from knot to knot, and commonly there are 32, 33, and 34 meshes in the yard. As the nets get older, through shrinking, there are 34 to 38, and even 40 meshes to the yard. During a fair fishing the new nets are regularly "barked" once a fortnight. Old nets require "barking" only once a month. "Barking" is the process of browning the nets by boiling them in cutch. The "swing rope" is a rope attached to the nets from the boat and is their safeguard, so to speak. The price of a net is in the meantime 33*s.*, which, together with mounting 4*s.* 6*d.* + head rope 12*s.* 6*d.* + buoy 4*s.* 6*d.* + floats 3*s.* + bark 3*s.* 9*d.* + fishermen's labour estimated at 8*s.* 9*d.* = £3 10*s.*; and therefore that is the sum to be paid for a fair average quality net ready for use. A boat carries from 25 to 50 nets, and that quantity is termed a "fleet." Making the lowest possible estimates appear by allowing only 25 nets to each boat, we have in use 153,275 nets, which at £3 10*s.* per net, gives the value of £536,462 sterling.

The baskets for the measuring of the herrings are supplied by the curer, and, sad to relate, in too many cases are slightly larger than the regulation size. The remedy lies with the fishermen, and they have themselves to blame if they do not take advantage thereof. The regulation measurement of the cran is 37½ gallons imperial standard measurement. There are 4 baskets to the cran, and each basket is exactly one-fourth of the aforementioned required standard measurement. In shape they resemble a common tub, but are wicker-worked, having in circumference two or three inches more at top than bottom. The rim of the basket is heavy worked and has two handles for fixing the hoisting rope and lifting. There requires to be on board the boat from two to four spades or scoops for shovelling the herrings into the baskets. Formerly they were entirely wooden, but now the heads are of zinc. The fishermen supply these spades; they cost from 2*s.* 6*d.* to 3*s.* each. Baskets cost about 2*s.* each. Making a fair allowance for each boat we find that these articles presently n use would give a money value of £5000.

Method of catch is thus explained: the boat and crew being ready to proceed to sea the crew get aboard and commence to "red," i.e. fold the nets in methodical succession, head-rope being to "stern," and foot-rope to "bow." To counteract the weight and position of the nets stones are used to balance. That finished, the boat is pushed or rowed out of the harbour, sail is hoisted, and, according to the state of wind and tide, is steered out to the fishing grounds. Arrived there, sail is lowered, and the nets "cast" or "shot" over the starboard side of the boat. The "watch" is set. Shortly before sunrise, and with the disappearance of the phosphoric light, the nets are hauled aboard and the herrings are shaken, weather permitting, from the nets into the "hold," and the nets folded methodically. Should the sea be rough when the hauling takes place, the nets cannot be shaken; but that no time may be lost, and to admit of the herrings being delivered in best possible condition, the fishermen always endeavour to have their nets shaken as they approach the harbour.

Delivery is here to be understood as from the boat to the carts on the quay. The fishermen shovel the herrings into the baskets and hoist them by means of ropes running through a "pulley" attached to the top of the boat's mast. When on a level with the quay, the carter, who has a rope fixed to the basket rope, draws to him, and the contents are emptied into his cart. A crew consists of five or six men and a boy, and in delivering the herrings, half of them attend to the filling of the baskets, and the other half to the hoisting. All have hard work, and there is no stoppage till every herring is delivered. The hoisting tells severely on the hands, and is not improved by the curious use of heavy worsted "mits" or gloves so often seen worn by the "hoisters."

FISH-CURERS—CURING YARDS—PLANT—COOPERS—ORAMEN—GUTTERS—KIPPERERS AND SMOKERS—CARTAGE—STOCK.

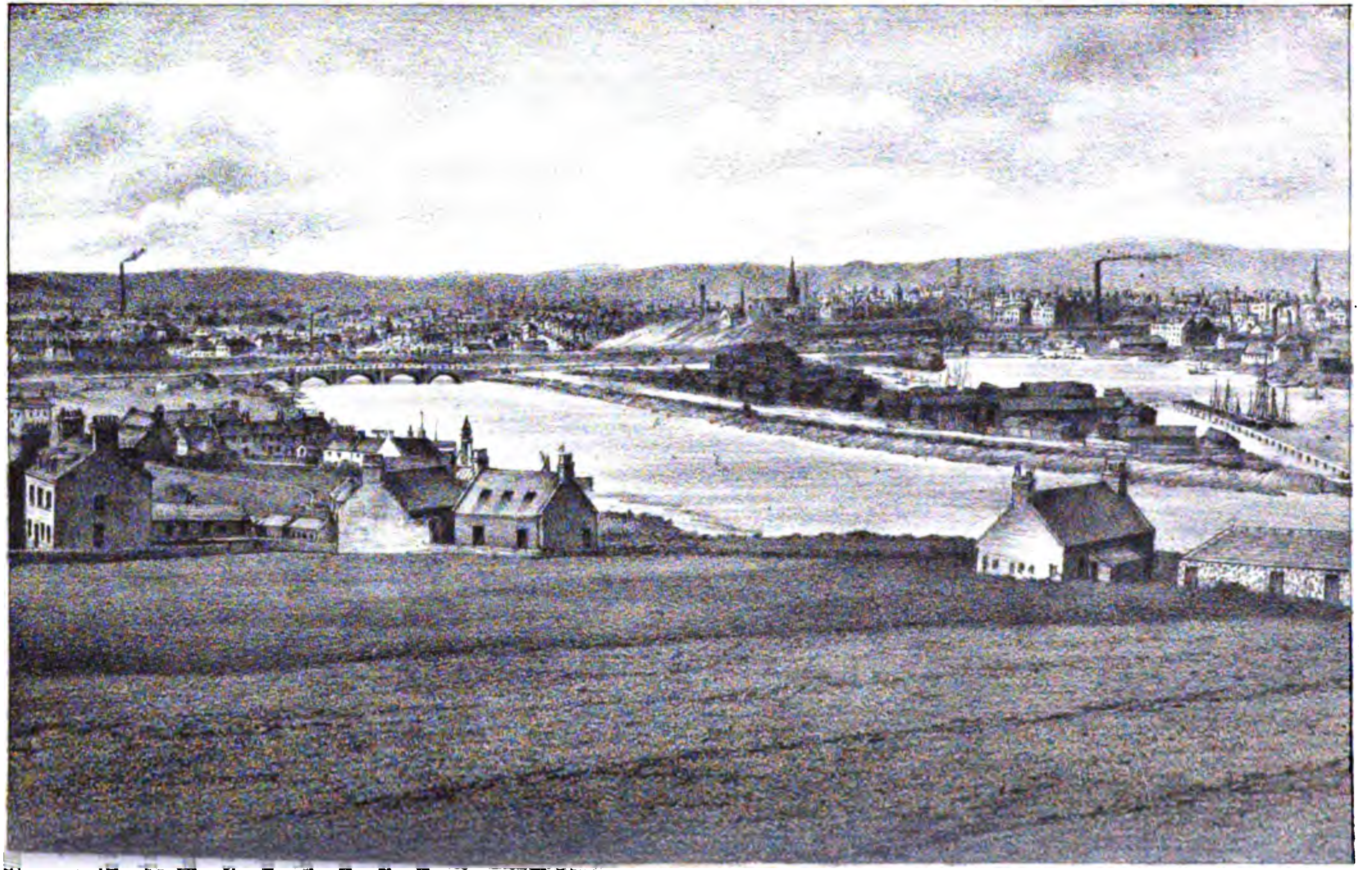
There are about 500 firms engaged in the herring curing trade on the East Coast, Orkney and Shetland, Lewis and Barra. The capital invested would amount to from £720,000 to £1,000,000 sterling. Of all classes they are always the most dependent, entirely relying on the sea's product; independent, meantime, by their position and standing; enterprising yet rash and speculative—none more so. They are industrious, and are deserving of the country's best thanks for so carefully, laboriously, even expensively, but not withal judiciously, conducting their business, the methods and results of which are so highly gratifying as to command the esteem of millions of people at home and abroad. They have raised to a high pinnacle the fame of the Scotch herring trade, and long may they preserve the position and honour.

Presuming that a herring curer has fully made up his mind as to the extent of his business, let us glance at his requirements. In the first place it is necessary that a suitable "stance" be procured, near or at the harbour, whereon the yard is to be erected. Supplies of wood (staves) and hoops are ordered, and suitable 'plant' is bought. The coopers are engaged. Boat-engaging time comes on, and the curer looks out for the good boats, and endeavours to engage them. After fixing his boats, he gives his orders for the salt required. If he is a practical curer and cooper he assists in the cutting and making of heads for the barrels, and otherwise superintends the business.

Curing yards are commonly square shaped. The buildings constituting a yard differ very much, in fact every locality has a different style. At Fraserburgh and Peterhead some very fine yards have been built lately. The frontages are of stone, and perhaps several stores are also of stone, but generally there are one or more wooden erections, stones, kilns, or coverings. At Pointlaw, Aberdeen, there are thirty-five yards, which are all, without exception, built of wood. This is owing to the short leases obtainable from the Harbour Commissioners. Pointlaw is part of the reclaimed ground at the Inches, and it is specially set apart for fish-curing.

The portion fronting the street or lane is generally the "gutting shed." Through a swing door or doors in the front of this shed the herrings are tumbled promiscuously, and fall into a large square box, or tank, called a "farlin," i.e. a repository for the herrings, where they are "roused," and await the process of gutting. Adjoining is the "cooperage." In front thereof, at a distance of a few yards, is the "firing-plate and truss-hoops." Sufficient storage accommodation is required for the barrels, salt, hoops and staves. Of late I have noticed an improvement in the gutting-sheds; I refer to the laying of the floors with concrete. It is worthy of mention that the fish-curers at Shetland, while laying out capital on their yards, are likewise under the necessity of providing "jetties," or landing slips near their stations at their own expense. I sincerely trust their enterprise will be rewarded. Shetland may be said to have risen within the past two years from insignificance to eminence. Whereas last year curing was carried on under difficulty, the catch being rather too heavy to be worked properly, the temporary curing yards seeming swamps, shipment difficult, communication limited, and

Plate II.



house accommodation more so, this year the curers will have nearly all the advantages to be had at home. The telegraph service is extended, as also steamer and land communication. Several substantial "jetties" have been built, and likewise good curing yards have been put up. Even the remote parts of the islands have every prospect of seeing a general merchant open business when the fishing begins. Barra, on the west coast, is by Lady Gordon Cathcart's assistance gradually rising from obscurity to significance, and although last year was a failure, it is to be hoped that the future fishings will prove a steady increase compared to the former years. Stornoway has now assumed the supremacy of the west coast, and has a large trade. On account of the Barra failure last season, Stornoway being extra-well fished, it is likely that there will be a great increase of boats next season (1883). The west coast fishing is for the greater part prosecuted by east coast curers, and, with the exception of Stornoway, all the yards are of a temporary character.

Plant consists of farlins (already described); small tubs or baskets for the various selections; large rousing tub; hoop-bending mill, costs about £11 to £15; head-boring mill, costs about £4 or £5; grindstone for sharpening tools; firing-plate and truss-hoops; crisset and fender; steep for soaking hoops; head and side jointers; head and side planes, or pluckers; adze for notching hoops; trussing hammer and drivers; shore, croze, and flencher or chime-howl; crumb or champhering-knife, head-knife, draw-knife; compass for taking the circumference of the barrel-heads; head and crosscut saws; two bits for boring the bung and spile holes; and stave-moulding axe, saw stool, head-cleaning board, dowl-dropper, and diagonal rod. Where there are kilns there are also required steeps for pickling the herrings, tenters or spits for hanging the herrings while being smoked, together with other small utensils which are hardly worth mentioning. Be it understood that quantities of the above articles are required according to the extent of the business.

The coopers steadily employed in the trade are about 3000 in number, including apprentices. During the herring fishing the journeymen, on an average, receive 33*s.* to 35*s.* per week. Foremen a few shillings more. During the winter their wages are earned on the work done. The principal employment then is barrel-making. A good man can make by steady work 24 barrels a week. The price for making a barrel is 1*s.*, and therefore the cooper can earn 24*s.* per week by steady work. He has a very responsible position, and is in reality the practical fish-curer. First, there is the necessity of making his barrels the exact regulation size, and showing an apparent good workmanship, tight fitting and well hooped. Second, care and punctiliousness in "rousing," i.e. salting to keep the herrings in good condition, till convenient to be gutted, and during the process of gutting. Third, the keeping in good working order all plant, and especially the farlins, tubs and gutting knives, and the superintending of gutting, selection, laying, and packing. Fourth, he has to devote particular attention to the pickling and filling up, and presentation for the brand. Although not receiving a remuneration equal in comparison to the amount of labour and responsibility, still, greatly to their credit, they are a contented, hardworking, thrifty, and energetic class of men, and by their excellent service are the instruments in making for the Scotch cure such a high fame as it has.

Oramen are only employed during the herring fishing season; 400 or 500 might be the estimate of the numbers employed. Their wages are about 20*s.* per week, and they are engaged to assist the coopers, and make themselves generally useful in the yard. Many of them are engaged as "cranners," that is, to attend to the delivery of the herrings from the boats, keep correct count of the baskets emptied into the carts, and in particular to see that the baskets are properly filled, and otherwise look to the interests of the fish-curer he is in service with. They are mostly of the labouring class, or persons out of employment.

"Gutters" are those engaged to gut the herrings on their arrival at the curing-yard. Women are employed as gutters. The fish-curer engages a "crew" of women for each boat. A crew consists of three persons. Two gut, and the other one packs the herrings gutted by them. There are over 20,000 women employed during the season. Their wages are at the rate of 8*d.* per barrel, gutting and packing, per crew. Those who are fortunately with a curer having a large average make a good sum of money for the season, but there are also those unfortunately with a curer with a poor average, and therefore their wages are comparatively small. The gutting of herrings is a laborious occupation. It is common in a yard to hear women singing cheerily at their work, they having commenced at mid-day and continued work in the same bent-figured attitude till the early hours next morning. Once commenced, there is *no* stoppage till the finish. While the herrings are before them, money is to be made. Work is no object. When the curer engages the gutting women, they are paid "arle" money of from 35*s.* to 55*s.* each woman, according to their known qualifications as "gutters."

Kipperers and smokers have quite a different class of work from the gutters. Kipperers, in the first place, have to "split" the herrings, and afterwards have to pack them into the boxes. They are generally engaged for about 17*s.* per week, but sometimes we find them working for 3*d.* per hour.

Smokers are the men employed to attend to the smoking, hanging up, and taking down of the herrings. They get about 27*s.* to 36*s.* per week, and considering the heavy work they are not overpaid. They are continually "heaping" the fires, and one can easily imagine the unwholesome vapours and heat to be simply stifling. It only requires an "anxious inquirer" to put his head in at the door of a smoke-house to convince him that a smoker's duties are onerous, most trying to the health, and exceedingly dangerous.

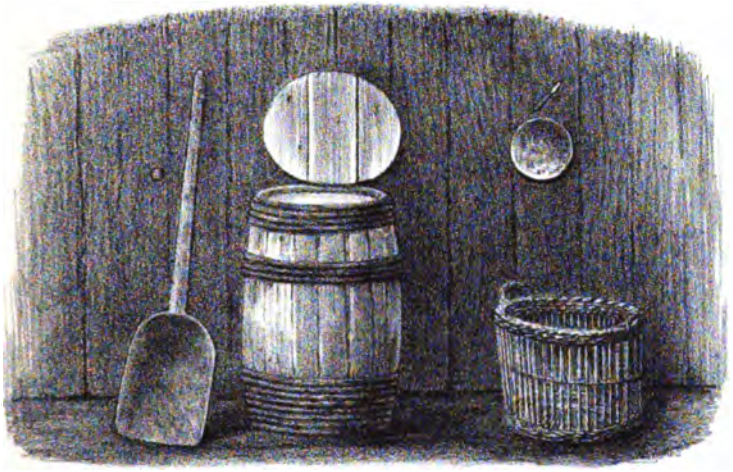
For cartage of the herrings from the boats to the yard, and when cured from the yard to ship's side for export, contracts are entered into between the curer and carter. The contract rates vary at all centres, but 2*d.* per cran from the boat to the yard, and 3*d.* per barrel from the yard to ship's side, may be given as the likeliest average. The best style of bulk herring cart is a long, even-balanced body-cart, and is specially adapted for the trade. A temporary division in the middle of a common cart prevents the herrings from slipping backwards, thereby tending to overbalance the cart and spill the herrings. For conveying barrels a "lorry" is the best. The income derived from the cartage of herrings for the past few years is not less than £15,000 per annum.

The principal articles of a herring curer's stock are staves and heading, hoops and salt. The curer may procure billet-wood and cut into staves by his own order; but generally the staves are delivered at the yard ready to be worked. The various woods used for barrel-making in the order of their value are larch, birch, ash, spruce, and Scotch fir. Larch is the dearest wood, and undoubtedly makes the finest barrels; costs from 80*s.* to 90*s.* per 1000 feet, and on account of its dearness is not so much used as it deserves to be. Birch is the medium quality, and is the most popular. Perhaps half of all the barrels made are of birch. Our greatest supplies are from Norway; Mandal and Pörsgrund shipping the best qualities. Our home supplies are indeed very small, and there is nothing in the quality of the home birch that particularly calls for comment. The price is at present firm at 75*s.* per 1000 feet. Spruce and common fir have of late years come much into use, and are appreciated on account of cheapness. Likewise the curers can be supplied by the neighbouring wood merchants at such times as they may require, and in small quantities. The price is from 60*s.* to 65*s.* per 1000 feet. These woods are very soft compared to larch or birch; and after the barrel has been filled with herrings and lain for 2 or 3 months in store, it is found that the pickle has become absorbed in the wood, the barrel has expanded, and therefore the herrings present a slackened appearance. I give it as my opinion that the less fir barrels are used the better for the trade. The curers may save a little in the price of the *barrel*, but they will certainly lose more than the amount in the sale of the barrels of herrings, for the simple reason that the German herring dealers have a dislike to fir barrels. It takes about 16 to 20 staves to make one barrel. 1000 feet of staves and 250 feet of heading will give about 70 barrels on an average. The nett cost of a barrel is from 3*s.* 3*d.* to 3*s.* 6*d.* according to the quality of the wood used. By these figures I estimate that it costs over £125,000 every year to prepare the stock of barrels for this herring fishing.

The hoops required for the barrel are in length 7½ feet, are about ⅜ inch thick, and vary in breadth from ¾ to 1 inch.

They are of wood, and are principally either of ash, birch, elm, willow, and hazel. The great supply of hoops are bought through London merchants, and are collected by them from all parts. The finest finished hoops come from Surrey. The cash price of hoops is for whole barrel 34*s.*, and for half-barrel 25*s.* f.o.b. London. From 16 to 18 hoops are required for each barrel. The money value for the total used during each year is not under £45,000.

The salt required by the curer is generally ordered about or immediately after the new year, and for delivery a week or two before the early fishing commences. The supply is calculated at from 12 to 15 tons of salt to the boat for a fair average fishing. Salt is in a great measure the responsible element in the cure, and it is therefore in the best interests of the curer to procure the best salt suitable for curing purposes. For "rousing," common salt is quite good enough, but for "packing and filling up" a great grained salt is required—first quality—is the proper requisite. Lisbon and St. Ubes salt has found much favour as a splendid salt for "packing," and on the west coast is much appreciated. However, this salt is not so much dealt in as its quality would warrant, but that is probably on account of the risk, measurement instead of weight, or a disinclination, from lack of sufficient profit, to deal therewith by the seller on this side. German salt has been tried at one or two stations, and its qualities proven satisfactory. It is, however, still in its infancy, and from all appearance may take some little time to get out of it on account of prejudice. I have had the pleasure of myself introducing it at Aberdeen, having contracted for 150 tons for July delivery. This salt is exclusively for packing and filling up. It is beautifully clear, great grained, and stands an excellent analysis.



Fishermen's Herring Shovel.
D^o D^o Basket.
Gutting-Women's Salt-Scoop.
D^o Knife.
East Coast Regulation-sized Herring Barrel and Head, shewing formation.

ENGAGEMENTS BETWEEN CURER AND FISHER—BOUNTY SYSTEM—ARLES AND DATES OF AGREEMENT.

The bounty system has been in force for a great length of time. From 1720 (perhaps before that time) to 1830 there were bounties at irregular periods given by Government to aid in the further development and extension of the trade. For interesting examples, I quote the following. In the year 1727 a Board of Trustees was appointed to manage the sum of £20,000 per annum allowed by the Government from Scotch Revenue (*vide* Act, 23 Geo. II.). Great encouragements were given and assistance rendered in floating the "Free British White Herring Company," whose capital was £500,000. Bounty was then paid at 30*s*. per ton on "busses" from 20 to 80 tons burthen. The year 1757 saw the bounty at 50*s*. per ton. We read of the Scotch having earned bounty in 1767, amounting to £31,396, but in 1781 only £9,674. In 1782 the bounty was reduced to 30*s*., not on the tonnage now, but on the ton of fish delivered. In 1808 we know of it having been paid in the form of 2*s*. for every barrel qualified, presented, and receiving the Government brand. It was raised to 4*s*. in 1815, and altogether withdrawn in 1830. Such was the bounty system of the olden times. Good in its way, and having its origin in the best of intentions—viz. to promote the development, and by its monetary assistance to encourage the trade.

The modern system is quite different, and to my seeming is a dangerous practice. It is a "bond," or "service," money paid by the herring curer to the fishers owning the boat as the part price of the contract. The following table shows the average amount of bounty per boat paid during the past six years. Before then the bounties were comparatively small, even as low as £5.

	1877.	1878.	1879.	1880.	1881.	1882.
Bounty paid . .	£20	£30	£40	£20	£40	£48

The fluctuations in bounty payments are entirely caused by the preceding year's catch and prices. Therefore the payments are purely speculative as to probable rise or fall for the coming year. A glance at the prices here given from the principal market—Stettin—will tend to prove this.

The quotations on 31st December were as follows:—

(Calculate 20½ mks. to £1.)

In	1877.	1878.	1879.	1880.	1881.	1882.
	M.	M.	M.	M.	M.	M.
Scotch Crownfulls .	44	38	52½–53	29–30	40½–41	38½–39
" Crown Matties	29	27–28	34–37	21–23	34–35	31–32
" " Mixed	27	25–26	35–37	22½–23½	32½–34	31
" " Spents	26	25–26	37½–38	22½	31½	31

The curers argue that to procure good boats good bounties must be paid. If bounties of a necessity must be given, then I agree with them. But why should bounties be paid? For example, take two boats both getting the same amount of bounty. One takes 100 crans, and the other 200 crans; in which case it would appear reasonable to expect that the catch of 100 crans should only receive half the bounty of the other; but it is not so. They both have the same bounty, but the one boat's fish is considerably dearer than the other; this to show that the bounty is not well or even-balanced. Again, if a curer has engaged eleven boats this year, he has paid out of his capital slightly more than £500 six or seven months before the fishing commences. There is an obvious risk in this speculative payment, and there is a chance of its being entirely lost. For instance, the Barra fishing last year (1882) was a complete failure. The bounty was £40 per boat. The curer's loss was averaged at £55 per boat. Had no bounty been paid, the loss would have only been £15 per boat.

To the fishermen this payment of bounty is supposed to assist them in passing through the winter, and to allow of improvements to their boats. As presents to the fishermen, without conditions attached thereto, such payments would be too highly commendable. But why not make this payment, if necessarily required by the fishermen, simply an advance to be repaid out of earnings? In some instances the bounty is misapplied, and it has been known to encourage laziness amongst the crews, especially in the early weeks of the fishing, when the cran is cheaper than in the regular set time. Bounties will come to a sudden stop the first year there is a backward and losing fishing. At present a good year to the curer means a greater speculative payment for the one that is to come, and that without any augury as to an equivalent return.

Arles are usually paid by the curer to the fisher over and above the bounty when the engagements are entered into. The arles are this year £1 per boat. As the fisher owning the boat has to "arle" his crew, I presume the £1 is given for that purpose.

The average bounty, including arles, paid on the east coast for the coming season, 1883, is about £48 per boat; inferior boats having £35 to £45; good boats £45 to £50; and first-class boats £50 to £53. Many boats are this year to commence fishing on the 1st July, but the engaged early fishing is from the 8th or 10th July till the 16th or 18th

July. The prices at these dates are 11*s.* to 14*s.* per cran. The regular fishing commences on the 16th to 18th July, and continues thereafter for eight weeks, or till the complement of 200 crans is delivered. In the event of a boat making its complement before the eight weeks are over, and exceeds it, the herrings can be taken by the curer at a less rate—14*s.* or 15*s.* per cran, but the curer is not bound to take them. The early fishing at Shetland commences this year during the first week of June. The price is 14*s.* or 15*s.* for the first 100 crans. The curers have it in their option to take more herrings at that money, or not. The regular fishing commences on the 1st July, and the price is 20*s.* for the first 250 crans. It is again in the curer's option to take more or not. The bounty and arles is on average £32 per boat. The native Shetland boats receive no bounty, and are engaged on the same terms as the "strangers." Curers on the mainland must have two stations (one on the west side, Scalloway, and one on the east side, Lerwick). This is accounted for by the theory that the herrings are only to be found on the west side during the first half of the season, and on the east side during the latter half. This theory may be correct or not, but at all events the curers and fishermen believe in it, and therefore the boats fish at two places, but under one agreement. The extension of the herring fishery at the North Isles only dates from last year. There are few stations on the west side, but all the season herrings were plentiful on the east side both early and late. The west coast fishing commences in the beginning of May, but the engagements generally run from the 10th May, the price being 15*s.* per cran. The regular fishing is from the 20th May till the end of June, and the price is 20*s.* per cran. The average bounty at Stornoway is £35 per boat, and at Barra £45 per boat. According to qualifications the prices are low or high. The inferior boats have as low as £30, and first-class boats as high as £50.

COPY OF AGREEMENT GENERAL WITH FISH-CURERS AND FISHERMEN.

"Sir,

"We, the undersigned crew of herring fishermen, having good boats and proper fleets of nets in our possession, hereby agree diligently and faithfully to prosecute the herring fishing for you at ——— and deliver to you all herrings we catch as per agreement during herring fishing season 188 commencing on the —— July at —— shillings per cran, till —— July, and from that date until eight weeks, at the rate of —— shillings per cran for two hundred crans, and —— shillings for all crans afterwards. All the herrings to be delivered in good (fisherman's) workmanship order and condition, before —— P.M. of the day after which we leave the harbour for the fishing grounds.

"Besides the above rates per cran we receive —— as bounty and earnest. You supply net ground and cartage of fish and nets. All herrings not up to terms of agreement we will offer you at what they are worth."

6d.
Agreement
Stamp.

CURING — FRESHING — KIPPERING — RED HERRINGS— TINNING—FAMOUS PICKLE CURE—A FEW REMARKS AS TO THE UTILITY OF FISH OFFAL.

The trade in sending to the English markets, inland towns, and the larger country villages, receives a good deal of attention, and is very lucrative, unless there be a heavy fishing, and therefore a probable glut. There are only a few fish-curers who work this " fresh trade." It is principally carried on by fresh-fish buyers, and they buy from the boats or the curers their daily supplies at prices according to the markets and prospects. Stornoway in particular does a large " freshing " business. To explain the " freshing," let us suppose a supply of herrings has been got. They are " roused " and well laid with small grained salt; straw, and perhaps matting, is put over the top of the barrel mouth and made firm. Boxes, barrels, or tubs will do, although iron-hooped boxes are the correct thing—and all that is wanted is expeditious transmission to the consignee.

There are a good many curers engaged in making kippers. A few of the many are long established, and therefore have a fairly wide known popularity as to their cure and merits. This coming season will see a great extension in kippering, as at large stations, such as Montrose, Aberdeen, Peterhead, Fraserburgh, Lerwick, and Stornoway, there are more curers entering on this branch of the trade. " Kippers " are at present a very popular edible, but there is only a limited home consumption, and as they do not keep their condition after two or three weeks, there is a danger in too fast extension, which will without doubt bring down the prices, and probably overstock the markets. It must be remembered also that the English cure a large portion of their catch in this style, and will prove dangerous competitors.

Red herrings are not cured so much for the home markets as for foreign. The countries around the Mediterranean are the largest consumers, and prices therefrom are good. The cure is thus described. The herrings are soaked in salt and saltpetre till they are rigid. The pickle is then removed. They are hung on the spits for a few days, and afterwards smoked until they are of the required colour. It takes eight or nine days to cure red herrings properly.

The tinning of herrings for the greater part is confined to Aberdeen, and Australia is the great market. Last year (1882) there were close on 2¼ millions of tins exported from Aberdeen for the various warm countries. There are from three to five herrings in a tin, and the tin and herrings weigh 1 lb. The process of curing and putting up is pretty much kept secret, and in case of mistakes I had better not endeavour to describe the method.

The famous Scotch pickle cure, the most important of all methods, now deserves special reference. The "pickle cure" was first practised as an article of trade in Holland in the year 1307. Immediately on the herrings being delivered by the carter at the yard, and deposited or "tumbled" into the farlin, i.e. gutting-tub, the coopers are careful to sprinkle them well with salt. This sprinkling of salt—called "rousing"—preserves and revives the condition of the herrings while they are being gutted. The gutting women lose no time in commencing their work. With their short knife in the right hand, and the herring in their left, they, by a dexterous and experienced movement withdraw the viscera and gills. All bloody matter is included therewith, and its withdrawal prevents the fish from turning a sickly colour, they would otherwise turn if the bloody matter remained. First-class cured fish keep beautifully clear and free from smell for nine or twelve months. After that time an unhealthy appearance makes itself manifest. As the herrings are gutted they are dropped into tubs according to their qualities. These tubs are placed close to the large gutting-box or farlin, and there is one for every selection. The gutters should be most particular in selection. The small tubs are carried by the "packers" to where the packing is taking place—generally in the centre, or open part of the yard—and emptied into a larger tub. Here they are again "roused." Two or three turns over with the hands is sufficient. In packing, the herrings are "laid" on their backs, and the packer sees that a proper quantity of salt is sprinkled over every tier. Attention is paid to pressing and refilling after the barrel has stood for a few days. Whereas small grained salt is the best for rousing, great grained salt is necessary for laying and packing. The various selections of the pickle cure on the east coast and Shetland are—1st, Fulls, i.e. full-sized, having roe or milt developed; 2nd, Matties, i.e. undersized, roe and milt immature; 3rd, Spent, i.e. spawned fish; 4th, Tornbellies, i.e. fish either split in the side, breast, or belly, while being gutted or torn in these parts in being shaken from the nets. The curers at various intervals—commonly near the end of the season—have another selection, viz. Mixed, i.e. matties and spents in equal quantities to be packed promiscuously in the same barrel. This mixed cure finds much favour with the North German and Russian dealers. I may also mention that since 1880—the disputing year—many curers are making two selections of the "fulls," viz. large fulls and medium fulls. This is praiseworthy of the curers, and in my opinion is the only way to keep the Mattie selection entirely distinct. Formerly, in a barrel of matties there was an equal—or very nearly so—quantity of small fulls. Such should not be. I say that immature fish—"matties"—should be kept separate from mature fish, even though the mature fish be small sized.

As the fish offal accumulates, it is carefully collected and transferred to old barrels set apart for that purpose. A barrel of herring offal realises from 1*s.* to 1*s.* 6*d.* per barrel. In the beginning of the season the farmers contract for a certain supply. Fish offal as a manure is now well known and appreciated as a good crop-raising stimulant. It is estimated that at the lowest possible over 75,000 barrels were taken delivery of by farmers on the east coast of Scotland alone, and the money value thereof to be not less than £5000 sterling. In its raw state the offal is, in the event of its too heavy application to the soil, apt to "burn." To prevent this burning it is apparent that it must have a compost. Our fishing centres should not be without manufactories for the drying and compressing of offal with such composts as, say, peat-moss, road sweepings, fine ashes and cinders from gasworks, or even from the common ash-pits. The composts are easily obtained, would make a capital all round manure, and for cheapness hardly to be beaten.

THE BRANDING SYSTEM—HISTORY—THE BRAND EXPLAINED—STATISTICS—QUALIFICATIONS.

In the 36th clause of Act of Parliament, 1808, we first hear of a brand on herrings. The presentment of a barrel of herrings of sufficient merit to receive the branding stamp thereon entitled the curer to the sum of 2*s.* In

1815, that sum was raised to 4*s.*, and thereat remained till 1830, at which date it was altogether withdrawn, but branding under the old regulations still continued. In 1859, a Parliamentary Commission of Enquiry reported favourably on the brand, and gave it as their opinion that the system of branding was beneficial in the interests of the curers, was a great facilitator of business—more especially in the foreign export trade—and was likewise a guarantee for the contents of the barrel and also the quality of the fish therein. A fee of 4*d.* per barrel branded was then imposed, and remains in force at this present day. Only lately has the brand received another vote of confidence, as it were. I refer to the report of the Select Committee appointed by the House of Commons in March 1881, to enquire into the expediency of continuing the system of branding herrings, &c. Their voting was as 12 against 3 that the brand was deserving of continuance.

The brand is a guarantee that the barrel is of the legal standard measurement, and that the herrings, for quality, selection, and packing, are up to the requirements of the Scotch Fishery Board. The brand is given to only four selections, viz. fulls, matties, spents, and mixed. There are twenty-six districts, and the branding officers employed throughout the whole, in 1882, numbered thirty-seven. As branding is now extended to Shetland, whose rapid growth is so visibly apparent, an increase in the branding staff must necessarily take place. The herrings to be entitled to receive the brand must be properly cured and packed, and have lain in the barrel twelve* clear days from date of catch. The curer signs a request note to the officer stating the number of barrels he desires branded. This has the officer's due attention. Previous to the examination of the "parcel," the officer receives a declaration to the effect that the herrings have been cured conformably to the regulations set forth, and also gets payment of the branding fees. He proceeds to examine the parcel, and to those entitled applies the branding stamp. The curer has had a fire prepared wherein to heat the officer's branding-iron, and when the iron is red-hot it is applied to the barrel, leaving an impression similar to the one here given. Every selection has a different stamp.

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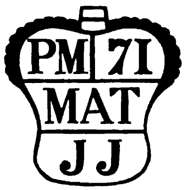
* The Fishery Board stipulate that to receive the brand the herrings must have lain *ten* clear days, *exclusive of catch and packing.* I therefore feel justified in quoting *twelve* clear days from catch.



The above is for Packed Matties, branded in 18–71, and the J J is the branding officer's initials. There is no brand given to the west coast herrings, nor is one required, as the herrings are not selected further than the curers deem expedient. Perhaps one-third may be selected, entitling them to the name of "prime" or "choice," the other two-thirds are packed promiscuously.

That the brand is highly appreciated, and yearly gaining in appreciation, the following results will sufficiently prove.

Year.	Barrels Branded.	Fees therefrom,	On Barrels.		On Fees.	
			Increase.	Decrease.	Increase.	Decrease.
		£ s. d.			£ s. d.	£ s. d.
1859	158,676	2,644 12 0	. . .	. . .	. . .	. . .
1869	244,522½	4,075 7 6	85,846½	. . .	1,430 15 6	. . .
1879	342,323	5,705 7 8	97,800½	. . .	1,630 0 2	. . .
*1880	689,286	11,488 2 0	346,963	. . .	5,782 14 4	. . .
1881	494,182½	8,236 7 6	. . .	195,103½	. . .	3,251 14 6
1882	462,612½	7,710 4 2	. . .	31,570	. . .	526 3 4

* The fishing of 1880 was the heaviest on record, in fact it proved by its unexpectedness quite too much of a good thing. We must therefore not consider 1881 as a year of decline, but, as it were, calculate proportionately as an increase over 1879. While 1882 proves another decrease, it must be mentioned that the branding officers were most stringently exacting in fulfilment of their duties, and the rejections were more numerous than in former years. The tenor of the quality under the brand is, in my opinion, raised thereby, and a continued strictness under the regulations as to quality and selection makes us hopeful that the brand will score a further success, and still remain prosperous in itself. The Lybster to Helmsdale coast fishing proving a comparative failure also helps to account for the slight decrease.

The brand is an excellent trade-mark, and as such facilitates the buying and selling. This last year (1882) the buying and shipping of herrings was commenced and almost finished within a period of five months. The number of barrels exported is given as 782,290½=(500 to 600 cargoes, and a money value of over £1,000,000). These figures give but a vague estimate of the immense business effected in so short a time. Every barrel bearing the "brand" may be bought and sold by local buyers to continental firms on the mere faith of the word "Crown-branded," and that *also without any examination whatever as to the contents of the barrel and the quality of the fish.* It is therefore plainly to be seen that the brand makes business transactions between the buyer and seller comparatively easy. As a contrast, I may state that the unbranded herrings are never bought unless subject to inspection before accepting delivery, or failing that, the seller's guarantee as to quality. Opinions as to quality may differ widely, and therefore contracts for unbrands are not only dangerous but difficult in negotiation. Also, inspection means labour. Labour is money. There is also time lost by seller and buyer. It is clear then that the brand is much to be esteemed, a valuable adjunct, and great facilitator of business, and it is to be hoped that the prestige it has given to the trade may never decline.

For further and more explicit information concerning the brand I would recommend a perusal of the essay on the herring brand—"Fish and Fisheries, 1882."

BENEFICIAL RESULTS — LOCAL TRADE — RAILWAYS — SHIPPING—BANKS—FOREIGN TRADE.

The benefits derived from the Scotch herring fisheries are marvellous in extent and distribution grand in results, and invaluable in wealth. Indirectly the shopkeepers of whatever nature in the herring districts are more or less influenced by its prosperity and continuance. In turn the merchants and manufacturers are benefited through the shops. An extensive and extending business means steady employment for manual labour, and by the necessity of supply so does the labourage increase. Directly, we have the fishermen and their families entirely dependent on the results; and labourers, gutters, coopers, builders, wood merchants, salt manufactures, railways, mercantile marine, banking, and in fact every trade and profession is receiving a support from this great industry. It is no exaggeration to say that the herring fishing is the great industry on whose success or decline the greater part of the Scotch east coast, Shetland, and the Hebrides hang their dependence. Any one acquainted with the Scotch coasts cannot fail to appreciate the great value of the herring fishing.

The basket and net manufacturers have a large field for their output. Every year there is a steady and heavy demand for baskets and nets. There are also the wood merchants at home and abroad being greatly benefited through the trade in supplying them with the different woods necessary for the making of barrels, as also the erecting of sheds and stores. Even the wood shavings or refuse find a good market with those curers who have kilns. Multiply the various instruments described under "plant" by 3000, and you will find that the instrument makers have to be exceedingly thankful for the trade. We must not lose sight of the great demand for wooden spades for the fishermen, salt scoops for the gutting women, gutting knives, hammers, nails, &c. Again, there is the tear and wear the boat, frequently requiring repairs or improvements at the hands of a boat-builder, a replacing of worn-out ropes and sails and all boats' gear. The wood-hoop merchants find a profitable and extensive business. Builders of fishing boats have been kept exceedingly busy during the past ten years. We must take into consideration the great number of people employed by the merchants and manufacturers in the preparing of the articles requisite by their necessary assistance to the carrying on of fishing and fish curing, all of whom by the demand are enabled to earn good wages. Last, but not least, let us glance at the salt trade. The quantity of salt used yearly is about 100,000 tons, and to the salt manufacturers gives a money value of from £55,000 to £60,000, nett, f.o.b., at places of shipment. The principal manufactories are represented at Runcorn or Liverpool, from whose docks the great bulk is shipped. I give this example to show that benefits are not confined locally, but here we have our sister country reaping benefit from the trade.

Railway Companies are greatly benefited by the vast traffic caused by the herring trade during the season. There is the continual carrying of fresh herrings to the English markets ; the occasional transfer of barrels, for export, from the smaller fishing districts to Aberbeen or other large centres for steamer shipment ; the carriage of supplies of wood from our home merchants ; salt occasionally, hoops, plant, and, above all, the great passenger traffic consequent on the temporary but necessary removings of the fishermen and families for the east coast traffic alone. I estimate that the charges made by the railway companies for the carriage of wood, staves, hoops, salt, plant, and of passengers and their luggage and other necessaries, and of fresh and cured herrings, would be at the lowest not less than £75,000.

Shipping has in the herring trade one of its greatest supports. Calculating that the average export for the past ten years is 600,000 barrels yearly, that would give as from 500 to 600 cargoes yearly. The average freights to the five principal herring-receiving ports on the continent, viz. Hamburg, 1*s.* 8*d.*; Stettin, 2*s.*; Danzig, 2*s.* 2*d.*; Königsberg, 2*s.* 3*d.*; and Libau, 1*s.* 11*d.*—total average 2*s.* per barrel. The total export for 1882 is given as 782,290¼ barrels, and therefore the gross freights would realise at the 2*s.* freight, £78,229 1*s.* A significant fact, showing the great importance attached to the herring trade by those interested in shipping, is to be found in the marvellous rapidly increasing building of superior steamers especially adapted for the carrying of herrings. Vessels of about 100 tons register are those principally engaged in the trade, and are most suitable.

The banks receive from the fishermen money on deposit at a moderate rate of interest (under 2½ per cent. for the past few years), and through the great amount of business arising from the trade, and their getting the bank notes put into circulation, thereby receive a great assistance, and derive a considerable profit. I calculate the deposits by the Scotch fishermen to exceed £500,000. As shown in a calculation made later on in this essay, the circulation of notes would be over £1,000,000 yearly. The fish-curers, although turning over a large amount yearly, and thereby being instrumental in the banks' circulation, yet are more generally debtors than creditors of the banks. Their capital is soon absorbed in bounties and stock, and in too many instances they are pretty deep on the wrong side with the bank, but generally such is balanced by heritable or personal security. When the boats are paid off, heavy temporary overdrafts are required. The fish-curer's reputation and character is sufficient to procure that. For some time past the North of Scotland Bank, Limited, has been fully alive to this important industry, and to their credit they have been the means at various centres—notably Fraserburgh—by their monetary assistance to curers, of furthering the development, encouraging its continuance, and of making by its extension a prosperity so plainly discernable. A sufficient compensation is found against the risk in the excellent interest charged by the banks for their accommodations.

The foreign export trade has now assumed an astonishing magnitude. It is not my intention to write regarding the trade in tinned herrings with Australia, or in red herrings with the Mediterranean countries, both of which are of considerable importance, but are comparatively insignificant as compared with the export of pickled herrings to Germany and Russia, of which I endeavour to make a few observations of interest.

In the early part of this century the demand for our herrings in Germany was very limited indeed. For instance, up till 1850 the Danzig market was sufficiently supplied with a yearly import of about 10,000 barrels of Scotch herrings. We must remember, however, that Germany was the great emporium of Norwegian herrings, and it was only on the Scotch cure and catch attaining the supremacy over all other herring fisheries that the demand in Germany increased. For, as the demand and favour for Scotch herrings increased, the prices gradually did the same, and to counterbalance which we have ample evidence that the prices and favour for all other kinds of herrings imported gradually decreased in a corresponding ratio.

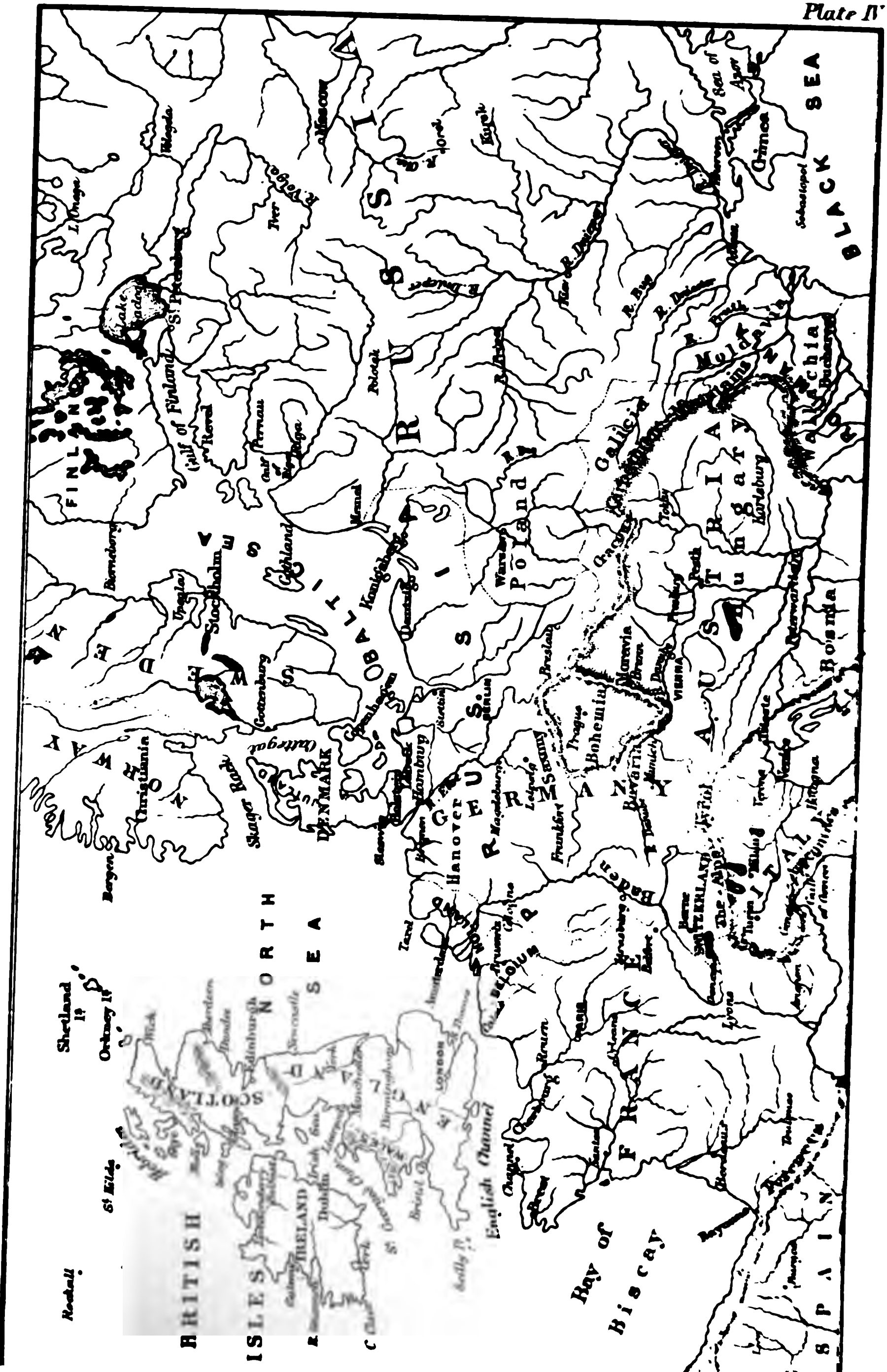
There are four great herring centres in Germany, viz. Hamburg, on the Elbe; Stettin, on the Oder; Danzig, on the Vistula; and Königsberg, on the Pregel; and whose imports for 1881 and 1882 are as under:—

	1881.		1882.
Stettin	248,336	..	267,107
Hamburg	112,349	..	150,612
Danzig	127,138	..	142,550
Königsberg	94,308	..	101,995
Total ..	582,131		662,264

These figures show that these four centres alone receive about five-sixths of the total exports from Scotland, and the exportation statistics are here given showing the various quantities shipped from the several districts in the respective years:—

	1881. Barrels.		1882. Barrels.
Stornoway	25,038	..	32,073
Shetland	47,594½	..	98,292
Orkney	5,990	..	10,658½
Wick	55,335	..	73,064
Lobster	17,183	..	2,912
Helmsdale	15,085	..	6,330½
Cromarty	746½	..	2,205½
Findhorn	7,660	..	3,781½
Buckie	9,360½	..	9,266½
Banff	25,080	..	24,131
Fraserburgh	165,362½	..	178,136½
Peterhead	158,155	..	156,026½
Aberdeen	83,206½	..	82,407
Stonehaven	13,723	..	7,359
Montrose	26,425½	..	27,662½
Leith	35,138½	..	46,607
Eyemouth	19,160½	..	21,377½
Totals for the two years ..	710,244½		782,290½
			710,244½
Showing an increase for season 1882 of ..			72,046

Plate IV


BLACK SEA
Sea of Azov
Crimea
Sebastopol
R U S S I A
Moscow
R. Volga
Tver
R. Dnieper
R. Bug
R. Dniester
Kiev
Wologda
L. Onega
Lake Ladoga
St Petersburg
Gulf of Finland
Reval
Gulf of Riga
Riga
F I N L A N D
S W E D E N
Stockholm
Upsala
Gottenburg
Gothland
N O R W A Y
Christiania
Bergen
Skager Rack
Cattegat
DENMARK
Copenhagen
B A L T I C S E A
Königsberg
Memel
Dantzig
Stettin
P o l a n d
Warsaw
Galicia
Cracow
Carpathian Mountains
Moldavia
Wallachia
Bucharest
Bosnia
H u n g a r y
Pesth
A U S T R I A
Vienna
Moravia
Brunn
Danube
Bohemia
Prague
Breslau
Saxony
Dresden
Leipzig
Berlin
Bavaria
Munich
Tyrol
G E R M A N Y
Hanover
Hamburg
Magdeburg
Frankfort
Baden
Strasburg
Cologne
Brussels
Amsterdam
SWITZERLAND
Berne
Geneva
The Alps
Venice
Trieste
Milan
Turin
Genoa
Bologna
I T A L Y
F R A N C E
Paris
Rouen
Orleans
Lyons
Bordeaux
Toulouse
Bayonne
Brest
Cherbourg
Bay of Biscay
Pyrenees
S P A I N
Oporto
N O R T H S E A
BRITISH ISLES
SCOTLAND
Edinburgh
ENGLAND
London
IRELAND
Dublin
English Channel
Shetland Is
Orkney Is
St Kilda
Rockall

A few of the other German ports are Harburg, Bremen, Lübeck, Pernau, and Memel, but they do not receive regular supplies. There are also numerous inland towns noted for their extensive transactions in herrings, the principal being Magdeburg, Halle, Leipzig, Breslau, Berlin, Frankfurt, Posen, and others of lesser note too numerous to mention. Russia seems to give a preference to Norwegian and Swedish herrings, the duty on which is much lighter than that on the Scotch. The duty on Scotch herrings is by far too heavy. Nevertheless, Scotch herrings to a limited extent command good prices through such markets as Libau, Riga, and St. Petersburg. These three Russian centres have a fair share of our west coast herrings, but they only receive a stray cargo now and then from the east coast. West coast and east coast early herrings, from their oily tendency, are in much demand at medium prices, but between the excessive charges and duty to be paid, the Russian people cannot afford to pay high prices. If the duty could be reduced to about level with the German, then an extended business would be the result; in the meantime the Russian prices and currency are of so fluctuating a character, that our curers and buyers must be cautious in the trade with Russia. However, Libau is strengthening its connection with us, and proving a great rival to its German neighbouring centre—Königsberg. Odessa, in the Black Sea, has lately been doing a direct business—principally through London agents—and it is hoped that such business will rapidly extend itself in the future. A glance at the accompanying map will show the situations of the centres I have referred to, and how admirably they command the interior business throughout Germany, Austria, and Russia.

CONCLUSION—HISTORY AND LEGISLATURE—STATISTICS SHOWING PROSPERITY AND WEALTH—MUCH REQUIRED AND EXPECTED IMPROVEMENTS REFERRED TO.

There is very little authentic imformation to be had regarding the Scotch herring fisheries before the sixteenth century. Having gradually risen from obscurity by slow but steady degrees, it was then in importance in close rivalry with the Dutch. There is mention made of the fishings as early as the 13th and 14th centuries, and as in the 15th century it must have left its mark on some of the old records of that time, surely, by diligent searching, some information might be got at once interesting and valuable.

From 1630 to 1650 a further impetus was given to its. prosecution, was successful, and apparently every year proved a steady increase. In 1676, a reaction set in, and its downward career was swift. The companies then in vogue were utterly quashed. However, private enterprise was quietly persevering, and thanks thereto, the herring fishing had by the end of the century actually got ahead of the Dutch.

From 1695 to 1707 success attended the enterprise and efforts of improvement. But the next seven years again saw a retrograde period, and the fishing nearly ceased altogether. This probably principal national industry was, by the stupid and complicated regulations and laws of the Legislature immediately after the union, nearly suppressed, and that at a time when its supremacy over other nations was most promising. In the years 1714, 1720, 1727, 1750, bold attempts were made to revive the trade. Large companies were again established, backed up and assisted by the Government, but the expected great results were never realised. A better year happened to be 1757, and the fishings kept steady thereafter till 1767, after which came the periodical backwardness, culminating in 1782, when we read the total catch was only 12,522 barrels for that year. The legislation of 1808, on fishery laws and regulations, laid the foundation of all its future workings, and it is from this period that we have a continual and progressive success. Several excellent alterations and additions were made by the Act 55, Geo. III. 694, 14th June 1815, and about this time the east coast seemed to be endowed with a new life. Herring curing seemed prosperous, and the small coast villages in many cases in a few years grew into fair-sized and prosperous towns. Perhaps the best example is Fraserburgh. Twenty years ago an insignificant 'Burgh indeed, but at this day the Scotch herring capital. Built on and around Kinnaird Head, it has the command of the Moray Firth. To the south lies its beautiful bay. Jutting out from the Kinnaird Castle is the breakwater, extending south and at the middle south-east, and shelters the harbours and the bay. It is 810 yards in length, and its average thickness about 30 feet. At its point there is a good lighthouse. The Balaklava Harbour at Fraserburgh is the largest herring boat harbour on the coast. It is 12¾ acres in extent.

The growing importance of the herring fishing has caused several inquiries and commissions to take place, and the results have always tended to its well-being. I refer to such years as 1832, 1843, 1852, 1859, and the more modern but the most important of 1881.

The following statistics show the total catch of herrings for the past twenty-six years, for the entire east coast including Shetland, Lewis, and Barra, viz. for—

1857	329,251 crans.	1869	403,633 crans.
1858	393,035 „	1870	596,421 „
1859	302,943 „	1871	562,865 „
1860	463,100 „	1872	562,737 „
1861	485,645 „	1873	714,717 „
1862	520,280 „	1874	720,964 „
1863	439,210 „	1875	655,606 „
1864	432,064 „	1876	406,440 „
1865	395,157 „	1877	561,439 „
1866	413,065 „	1878	618,597 „
1867	474,098 „	1879	516,406 „
1868	366,068 „	1880	930,307 „

	1881. Crans.	1882. Crans.
Stornoway	41,950	45,980
Shetland	46,500	102,250
Orkney	14,418	16,018
Wick	61,742	81,792
Lybster	16,688	1,730
Helmsdale	16,388	6,404
Cromarty	1,638	1,376
Findhorn	6,890	4,872
Buckie	7,173	7,630
Banff	22,106	23,003
Fraserburgh	132,642	139,451
Peterhead	124,878	124,185
Aberdeen	78,702	80,363
Stonehaven	19,355	15,910
Montrose	26,012	28,820
Leith	7,216	3,660
Eyemouth	59,486	59,825
	683,784	743,269
Deduct season 1881		683,784
Showing an increase for season 1882 of		59,485

And for the past five years the total catch at the individual stations :—

Stations and Districts.	1878.	1879.	1880.	1881.	1882.
WICK	84,248	63,094	113,186	55,542	69,926
Lybster and Clyth	6,910	9,240	12,371	15,231	1,626
Forse	282	620	592	219	28
Latheronwheel	512	790	637	1,237	78
Dunbeath	1,502	2,800	1,056	1,802	504
Helmsdale	7,600	10,855	10,285	13,783	3,920
Portmahomack	858	1,391	1,790	1,515	1,376
Burghead and Hopeman	1,122	3,009	5,200	3,090	2,328
Lossiemouth	819	4,896	7,600	3,800	2,544
Buckie District	2,864	3,832	12,413	7,173	7,630
Portsoy	4,935	4,670	6,950	5,600	4,650
Whitehills	1,102	1,610	1,667	840	1,174
Banff	250	1,360	1,913	1,606	3,030
Macduff	4,756	7,384	8,530	5,538	9,762
Gardenstown	4,058	7,007	6,915	7,685	4,387
Fraserburgh	175,820	105,037	218,504	132,613	139,500
Peterhead	122,456	83,200	177,300	124,800	124,185
Aberdeen	69,231	36,400	78,810	78,657	80,253
Stonehaven	..	..	..	..	15,910
Montrose District	26,758	30,048	54,091	45,352	28,820
Anstruther „	3,975	6,490	7,840	3,660	3,145
Leith to Dunbar	1,500	5,460	4,600	4,110	2,722
Eyemouth District	25,407	52,149	48,715	59,486	59,825
Orkney	14,722	8,364	16,142	14,418	16,160
Shetland	6,240	6,700	38,700	46,250	102,000
Lewis and Bárra	50,670	60,000	94,500	41,100	45,240

Stonehaven has been this year disjoined from the Montrose district, and erected into a separate station. In the foregoing tables we therefore give the results for 1882 separately, although for the previous years they are all included in the Montrose district.

A perusal of the foregoing statistics will prove that although yearly fluctuations have taken place, yet that every periodical decade proves that the prosperity as regards the catch is steadily on the increase. The quality and selection have also much improved, thanks to wise regulations and our national characteristic intrepidity. The prices also are year by year becoming more firm, are less speculative, fluctuate less than in former years, and are now entirely regulated according to supply and demand. The supply, apparently always increasing, is at the present moment very great, but it is pleasing to state that the demand is proportionally quite as great and strong.

In recapitulation, the following calculations are here given to show the reader some idea as to the wealth of the herring trade.

CAPITAL.

	£
Fishermen's boats, all necessary gear included—	
6131 boats at £275 per boat	1,686,025
6131 boats' "fleets" of nets at 70*s*. per net, allowing 25 nets to each boat	536,432
Fish-curer's invested capital, lowest estimate . . .	720,000
Total ..	£2,942,457

ONE YEAR'S BUSINESS (1882).

	£	*s*.
Bounties paid to fishermen—		
6131 boats at £40 per boat	245,240	0
Prices paid to fishermen for herrings—		
743,269 crans at average of 18*s*. per cran . .	668,942	2
167 new boats, with all necessary gear, at £310 per boat	51,770	0
167 new "fleets" of nets—30 per boat, at 70*s*. per net .	17,535	0
For new nets distributed amongst the fleet . . .	15,000	0
Lowest estimate for repairs on the fleet (paid to boat-builders, rope and sail makers, block and tackle manufacturers, Cutch dealers, &c.) . . .	12,500	0
Total paid "to" and "by" fishermen ..	£1,010,987	2

Fish-curer's outlay, interest on capital, rent of yard, plant, stock and work, wages to coopers, gutters, labourers, cartage, shore dues. Equal to about 8*s.* 6*d.* per barrel	£394,862
Fish-curer's income—return for herrings— 743,269 crans = 929,086 barrels at 30*s.* per barrel	£1,393,628

We must not forget that the fishermen own seven-eighths of the houses they inhabit, and also, that they are heavy depositors with our Scotch banks. Many of the fish-curers are affluent, and possess both money and property. Likewise, the Scotch buyers for foreign export, who may be said to turn over once more the great money circulation of this trade.

Of the much required and expected improvements, it is apparent that harbour accommodation is the most needed. It is gratifying to note that the surplus branding fees are to be devoted in that improvement, and that a large Government grant may be shortly expected for an east coast harbour of refuge. Whilst large centres are receiving every assistance, even at present, there are small centres who receive little or none. Some are most deserving, and ready to spring into a new energetic life whenever they get a new harbour, or an extension.

With a rapidity quite amazing, the improvements in our boats, gear, and nets, have sprung into force within the past dozen of years. The herring fishing is year by year being prosecuted further from the shore, and large and finer sea-going boats are becoming necessary. If such continues, to prevent the quality of the fish retrograding, the application of steam to our fishing boats will be necessary. Already I can see symptoms of an east coast steamboat herring fishing.

Last, but not least, comes the great necessity for improving the social condition of our fishermen, and especially of providing suitable and proper accommodation for them at the herring centres. I sincerely hope that circumstances may arise at an early date that will demand an inquiry, the result of which will tend to the much needed rectification of a backward mode of living. A very slight monetary expenditure and a few forcible regulations are all that is requisite to right this matter. The success of the trade is due in a great measure to the fishermen and their steady enterprise, but they have nearly gone as far as they can; at least, it is not their business to provide temporary residences at every place they may go to fish. It must therefore lie with the curers (employers), or through Government agency to provide the needful. Our fishing is progressive, so let us hope that our fishermen will also be so. Progress the watchword, and Prosperity the result.

THE

NATURAL HISTORY

AND

CULTIVATION OF THE SOLE.

> "*Soles, the everlasting Sandals of the Immortals.*"
>
> Σάνδαλα ἀειγενῆ ἀθανατάων·
> βούγλωσσον.
>
> (ATHENÆUS, *Deipnosoph.* 136 b.c.)

[REV. W. HOUGHTON, M.A., F.L.S.]

THE NATURAL HISTORY
AND
CULTIVATION OF THE SOLE.

OF all our commercial sea fishes there is, perhaps, not one that is more highly or more deservedly esteemed than the common sole. The flesh is firm, nutritious, and of delicate flavour; it is free from oil, and on that account it is a fish easy of digestion, and well suited to the requirements of the invalid. It is readily cooked, and prepared for a meal at a few minutes' notice. The sole, therefore, possesses all these important characters which have caused it to be more sought after than any other fish, by those persons who can afford to pay a high price for it. Of late years the comparative scarcity of this fish in relation to the great demand for it has caused it to become the most expensive article of sea-fish diet, and many people who formerly could afford to enjoy their favourite fish at a moderate cost, are now constrained to buy it but rarely, or to give it up altogether Let us first consider, (1) The natural history of the sole; (2) then those causes, if they exist, which have been alleged as creating a diminution of this fish in its own waters; (3) lastly, let us see whether the sole may be artificially cultivated, as we know to be possible and easy in respect of some of our freshwater fishes, notably the *Salmonidæ*.

The sole, *Solea vulgaris*, belongs to the family of *Pleuro-*

nectidæ, a word which in the Greek means "side swimmers." The term "flat fish" is the one usually employed to denote this family of fishes, but we must distinguish between these flat fish which are side swimmers, and other kinds of fishes also called flat fishes, I mean the rays and skates. The sole and all the Pleuronectids are flattened on the sides, the rays or skates are flattened from above. The upper surface of a skate, i.e. the dark or coloured portion, is the back; the dark or coloured surface of a sole or other Pleuronectid is one of the sides. The skate swims on its belly like other vertically-swimming fishes; the sole, turbot, flounder, &c., swim on one of their sides; sometimes on the right side in some species, as in the turbot and brill (*Rhombus*), and sometimes on the left side, as in the sole (*Solea*) and plaice (*Pleuronectes*). It is a very curious and interesting fact, however, that this characteristic mode of swimming, or resting on the ground, among *Pleuronectidæ* is not very peculiar to the young fry of these fishes, which in their very earliest stage, after they have left the egg, swim in a vertical form like other fishes; and not only so, but the eyes, instead of being both situated on the same, i.e. the coloured side of the body, as in the adult, are in the very young, one on the one side and the other on the other side of the little fish; moreover, whereas as a rule, to which, however, there are occasional exceptions, one side is dark or coloured in the adult, in the very young fish both sides are coloured, and the numerous pigment cells are as well developed on the one side as on the other. This curious fact in the structure of the young of the *Pleuronectidæ*, though well known to those who have studied the natural history of fishes, is not known to the generality of people, and I find that fishermen are altogether unaware of this phenomenon, with here and there a solitary individual who has been in the habit of looking closely into the forms of the creatures he so constantly has an opportunity of capturing. And since, in any account of the natural history of the sole, it is desirable to speak of it "*usque ab ovo*," it will be well here to notice what has been absolutely observed in the case of young fishes of the same family as the sole. I am not aware whether the very early life of the sole has been definitely recorded by observers in this country or on the continent, but what is true of the young of some other flat fishes is probably and almost certainly true, in its general and characteristic features, of the young of the sole; so that although we are ignorant at present of the actual form of the early hatched fry of the sole, we are pretty safe in believing that its form and habits, at that time, differ in no important respects from the form and habits of those species in which this vertical form has been observed. A knowledge of the manner of spawning in fishes, the places which they frequent for that purpose, the mode of deposition of the ova, whether, as in the case of the herring, in a compact viscid mass of large or small size at the bottom, or on weeds or other submerged bodies, and in several other known sea-fish genera or species, or whether, as in the case of the many of the Pleuronectids, Gadoids, and other fishes, at or near the surface of the water, the conditions necessary for the development of the spawn, the places favourable for the growth of the fry, questions relating to currents, storms and temperature, the food of the young fry of fishes, the natural destructive agencies at work among them, all these are points in the natural history of all our fishes which we must know something of, if we expect to meet with any success in the propagation and cultivation of any particular kind. It is unfortunate that, with regard to the sole, there are many questions which still await investigation and explanation, but it is to be hoped that the interest excited by the International Exhibition will awaken in many observers a desire to penetrate into some of the mysteries of fish life, and especially into those connected with the natural history of the sole, whose claims present themselves with more than ordinary force and merit. Again, proposed legislative interference may be productive of much mischief, and thwart the very objects such interference has in view, unless it is based on a knowledge of the natural history of the fish which it is desirable or possible to protect from the effects of reckless modes of fishing, or from other injurious effects. The commonly accepted but now proved erroneous notion that all our sea fishes, except the herring, spawn near the bottom of the water, and that the trawl works unspeakable mischief by destroying the spawn, prevalent amongst so many of our fishermen, might have brought considerable loss to our fishery supplies, had any law been passed prohibiting trawling at certain times of the year or limiting the size of the mesh, &c. Now, from increased knowledge, we see the mischief that might have ensued ; very few of our sea fishes deposit their spawn in masses at the bottom ; nearly all, or at any rate the most important, of our commercial sea fishes emit their spawn near the surface, and there the eggs develop, and there the young fry for a time feed and disport themselves ; while there is little doubt that the sole is a surface spawner, and that its fry are in their early days vertical swimmers, with eyes one on each side of the head symmetrically arranged ; that both its sides are coloured, and that the changes that take place both in the position of the eyes, the mode of swimming, and the colouration are similar in general and essential respects to the changes which Professor Agassiz has observed to take place in the flounder. I will here give some account of what Professor Agassiz has made known with respect to the young state of the "flounder," because the subject is not only one of great interest in a zoological or physiological point of view, but what has been observed to take place in that fish may be considered as typical of analogous phenomena in the structure, colour, and habits of the young sole. "A young flounder," says Agassiz, "immediately after its escape from the egg, presents no special points of difference from the embryos of other bony fishes in a similar stage of growth. The young flounder has already attained a considerable size before any signs appear of the change in the position of the eye on the left side, and before the young fish shows the least tendency to favour one side more than another. Not until the young fish is fully three-eighths of an inch in length can the first slight difference be perceived in the position of the two eyes when seen from above. All young flounders, even long after they have all the characteristics of the adult, very frequently swim vertically for quite a length of time, or else swim near the surface with the undulating movement they have when swimming over the bottom, their heads well raised and bodies carried flat, parallel to the surface. Even quite old flounders are caught swimming near the top of the water. Almost all the stages were caught near the surface, swimming vertically like any other bony fishes; but this they do only when they come up to feed, while the water is very smooth, about ten in the morning, on very light sunny days, when they may be seen eagerly devouring swarms of embryo crustaceans of all orders. The young of other fishes seem to share this habit; for of the latter I have examined no less than twenty-five species, caught at various times with a hand-net, swimming near the surface of the water on bright sunny days, when not a ripple ruffled the sea. With the least movement, all the more delicate of these embryos vanish, leaving only the older and more vigorous, which in their turn disappear, and seek shelter in deeper water. Only when the young fishes are old enough to be recognised as the young of their tribes, do they venture to join them in their ordinary haunts. The habits of young flounders differ greatly from those of the adult; while the latter are generally more or less sluggish, the young flounders, when measuring less than a couple of inches in length, are remarkably active, bounding through the water, as it were, and if disturbed, frequently jumping out of the flat dishes in which I kept them." Dr. Alexander Agassiz's investigations, as above, refer to species of *Pleuronectes;* the same characteristic changes have also been observed by him in the genera *Rhombus* and *Pseudo-rhombus* and *Plagusia.* Whether Agassiz or any other observer has actually remarked the same changes of structure and habits to occur in those species of the genus *Solea* which are found on the Atlantic coasts of America, I am unable to say; but it is not too much, I think, to assume that analogous changes are characteristic of the genus *Solea,* and we may therefore be right in believing that the early life of the young sole differs in no essential particulars from the early life of the Pleuronectids generally. Indeed, it would be a very remarkable anomaly if the sole differed in these respects from the other members of the family of *Pleuronectidæ.* The sole has a wide geographical range, being found in the seas of Scandinavia up to latitude 62°, in the Baltic, where it does not penetrate very far, around the coasts of Great Britain and Ireland, and southwards into the Mediterranean. The soles of our southern coast are superior to those of the north; the warmer climate is better suited to this species, for the sole is very susceptible of cold, and either retires into deep water or hides in the mud or sand during severe weather. Sandy shores mixed with mud are its favourite places of resort, but it is very erratic, and any calculations as to the probability of finding its whereabouts are uncertain. The cold, however, nearly always drives the sole into deep water, into whose comparatively warm depths they will come from some distances, as is proved by the enormous captures occasionally made in what are called the "Silver Pits," or rather the "Outer Silver Pit," a patch of about 60 miles east and west, and from 6 to 10 miles wide, near the Dogger Bank in the North Sea.

With regard to their spawning, there seems to be no doubt that the usual time is in the spring, from February till about April; but, as in all other fishes, the time varies according to the temperature. They seem to frequent the shallower parts of our shores about the time of spawning, and like many other fishes appear to select shore water for this purpose, although it is not improbable that they often spawn also far away from land. The ova doubtless float like those of many other sea fishes, with whom floating ova seem to be the rule. Mr. J. Epton thought that small bunches of spawn, which he found in the summer of 1880 adhering to the warp of the net in the "Well" (North Sea), were those of the sole's eggs. He examined them carefully, and compared them with the eggs of soles spawning at the time. He speaks of them as hanging in suspension; one would be inclined to refer these suspended clusters as rather those of the squid or some molluscous creature; at the same time, I believe, the eggs of the sole after being deposited are as yet undetermined. Shallow water appears to be more or less essential to the development of the eggs of those fishes which deposit them on the ground, generally speaking;

this is especially noticeable in the *Salmonidæ*, which require a depth of three to four inches at least, not more. Perhaps the influence of the light and the more complete aëration of the water are the conditions the eggs require and meet with in shallow waters; still there seems to be no definite rule herein, for the spawn of herrings is often met with in deep water some way out at sea. But for the floating ova light and air seem to be essential.

The growth of the sole, like that of all other fishes, depends in a great measure on the quantity of nutritive food it is able to take. Mr. Epton says that at one year old soles are about 2 to 4 inches in length; at two years from 5 to 9 inches; at four years some contain spawn; and at five years they are large soles, and that they continue to grow slowly a few more years ('Fish and Fisheries,' p. 249).

The vicinity of a shore is more generally favourable to the growth of the young of fishes than the wide and open parts of the sea, on account of the profusion of life both of animal and vegetable nature that usually abounds there. Again, the neighbourhood of estuaries and large rivers which carry with them in their course great quantities of mud containing organisms in a living or decomposed or semi-decomposed state is favourable, because many fishes, and the sole especially, swallow large quantities of mud, and derive nourishment from the organic matter, often, it is true, of a microscopic size, which the mud contains. Hence the frequency with which we observe an abundance of young fishes near our coasts. Few people, unless they have microscopically examined the contents of fishes' stomachs to a considerable extent, are aware how much food fish derive from the mud which they swallow. The intestines of soles are often quite black from this cause; and if the stomach and intestines be opened and the contents examined in a shallow vessel of water, the particles of sand and dirt at once reveal themselves. We can see in the case of our common earth-worms, we can see in the case of the well-known lugworm (*Arenicola piscatoria*), how sustaining to animal life is the soil of the land and the mud of the sea-shore. Large bodies are fed and nourished often by the smallest particles of food, provided those particles are taken into the stomach in large quantities.

If portions of the contents of a very small sole's stomach be examined under the microscope we shall find remains of minute chætopodous worms, themselves mud-eaters ; small entomostracous crustacea, and not unfrequently diatomaceæ ; very minute bivalve shells, and other things not easy to determine. As soon as the umbilical sac in an embryo fish has disappeared, so soon does it require food ; and excessively minute matter is only suitable for the tender mouth and stomach of the young sole. For the short space of time, I do not know for how many days, during which the young sole is a surface swimmer, its food must be obtained at or near to the surface. The surface food at this time consists of the minute particles of matter which the sea water always holds in suspension, floating alga, protophytes, and potozoa ; the young of the *Copepoda*, and other microscopic atoms of animal or vegetable life. As the young sole grows, it sinks to the bottom and draws its sustenance from thence. Fishes are, as a general rule, either surface swimmers or ground swimmers ; they are either within a few fathoms from the surface or near the bottom ; there does not appear to be an intermediate stratum where they habitually dwell. From researches made by Professor Agassiz in the United States Coast Survey steamer the *Blake*, in the summer of 1880 and 1881, it seems certain that there is no intermediate belt of animal life of any kind between those forms which live on the bottom or close to it, and the surface pelagic fauna; that, in fact, the surface fauna of the sea is really limited to a comparatively narrow belt in point of depth. "As far as the pelagic fauna is concerned, those who have been in the habit of collecting surface animals know full well that the last ripple will send them below the reach of commotion. Müller and Baur were the first to adopt the use of a tow-net below the surface to collect pelagic animals when the water was disturbed. It seems natural to presume, as we have found from our experiments with the Sigsbee cylinder, that this surface fauna only sinks out of reach of the disturbances of the top, and does not extend downward to any great depth. The dependence of all the pelagic forms upon food which is most abundant at the surface or near it, would naturally keep them where they found it in greatest quantity. Of course, with the death or decomposition of the pelagic forms, they sink to the bottom fast enough to form an important part of the food-supply of the deep sea-animals, as can easily be ascertained by examining the intestines of the deep-water Echinoderms." These remarks of Prof. Agassiz are made more especially in connection with deep-sea forms of life, forms which can exist and thrive and multiply at a depth of even 2000 fathoms; but they apply, I conceive, with equal force to those surface forms of organic life which are found in boundless profusion at certain times of the year in sea water whose depth is not much more than a few fathoms.

The young sole, if born in shallow water, has not many fathoms to sink ere it reaches the bottom; and in such water, near the coast, there is almost always a profusion of minute living organisms which serve it as food. In deeper water, where young soles are undoubtedly found—I have seen young ones taken sixty miles or more from the land in the North Sea, in water about twenty fathoms deep—it is probable that they derive part of their food from the dead surface animals which, as Professor Moseley says, "fall as a constant rain" upon the deep-sea forms of life. Of course, at the bottom of the water young soles would find plenty of suitable food in living creatures there; food would be also found in the decomposed bodies of animals which perish as it were *in situ*, and which the water would hold in suspension. From an examination of a great number of soles, I cannot help laying stress on the large percentage of food which soles take into their systems, by swallowing, directly or indirectly, portions of mud which contain living organic forms and decomposed animal or vegetable matter; such food they will obtain both from the surface and the bottom. This fact has an important bearing on what will be said in connection with the question, "Will soles live and thrive in fresh water?"

Soles, when they arrive at maturity, are able to take food of a substantial nature in the shape of other fishes—crustacea, when not large, as crabs of various species; molluscs whether univalve or bivalve; but I have found in their stomachs more of the latter than the former, especially *Syndosmya alba*, adults and small, *Tellinæ*, young razor shells (*Solen*), and other thin-shelled bivalves; for the sole, unlike some of our other sea fishes, has not a "strong stomach," so far as its muscular walls are concerned, and I doubt whether hard-shelled univalves, though occasionally swallowed, form a large constituent in their diet. The sole is especially fond of worm-food, such as large lug-worms (*Arenicola*), *Nereis* and *Eunice*, *Phyllodyce*, &c. I must here remark that the result of a great number of the examinations of various fishes' stomachs is only so far of value as an indication of the *general nature* of their food, An examination shows what a fish has fed upon at the time it has been caught; it is quite probable that, were it possible to extend observations, various other kinds of food would be found in the soles' stomachs, sometimes of a kind that one would hardly expect. A sole may have a predilection for one kind of food more than for another, but food of some kind it must have, and therefore soles' food must depend upon the locality in which they are found, and the choice of locality is not always within the fish's own power, on account of temperature, currents, or other causes.

An important point which bears upon the artificial cultivation of the sole is its undoubted tenacity of life. I have taken soles of about four to six inches in length from a shrimper's net, have put them with a lot of other small fishes, as dabs, flounders, &c., in a collecting can, taken them home as they were, and set them in a cool place; whilst most of the other little fishes were dead, the soles were alive, after having been out of the water for twenty hours; and this tenacity of life is corroborated by fishermen who collect specimens for our aquaria. Soles do well in an aquarium, and there is no difficulty in getting them safely there. Why one fish should be tenacious of life, and another of the same family, and even of the same genus, should prove to be quite the reverse, is a fact difficult of solution. A closely allied species of the *Solea vulgaris*, for instance, the *S. minuta*, "solenette" or "little sole," soon dies in confinement. While out in a shrimping boat off Southport in April of the present year, collecting specimens for the aquarium, we caught a great number of "solenettes," but the fisherman said "they were no good," because they would not live in confinement many days, and this was confirmed in the case of those I brought home, for not a single individual survived.

I will here observe that, for any one interested in the natural history of fishes or any subject connected with marine zoology, a day with a shrimper will be sure to result in the acquisition of various treasures. In my investigations of the stomachs of fishes, I have always found it very difficult to get hold of the fishes before they were "gutted." If you buy a fish in the market it is almost always "cleaned;" the gills and stomach, &c., are taken out, and there is nothing left for the naturalist to examine if his object is the determination of the nature of the food. To examine the contents of a fish's stomach you must go out with a trawler or a shrimper, unless you have a boat and appliances of your own. Prime fish are nearly always gutted on board.

The finest soles are caught on our southern coast, as at Brixham and Plymouth and off the Cornish coast. Thompson's largest specimen was twenty inches in length. Mr. Grove received one from Torbay in February 1882, which measured twenty-four inches, and weighed 6½ pounds. Mr. Buckland had casts of a pair caught off the Irish coast which weighed twelve pounds; and Yarrell speaks of one weighing nine pounds, which measured the great size of twenty-six inches; and I suppose this to be about the largest recorded.

Soles are frequently anadromous; they are fond of the neighbourhood of estuaries and of ascending rivers for some miles, quite out of the reach of tidal influence. When I was in Devonshire I was told by the fishermen of the Dart that soles are often caught up the river as far as Totnes, and that they are very fine. An authority mentioned by Yarrell—a gentleman who resided on the banks of the Arun—writes: "I succeeded yesterday in seeing the person who caught the soles about which you enquire, and who has been in the constant habit of trawling for them with a ten-feet beam trawl for the last forty years. The season for taking them is May till November. They breed in the river (Arun), frequenting it from the mouth, five miles upwards, which is nearly to the town of Arundel, and remain in it the whole year, burying themselves in the sand during the cold months. The fisherman has occasionally taken them of large size, two pounds weight each, but frequently of one pound; and they are thicker in proportion than the soles usually caught at sea; in other respects precisely the same. And it is evident that they breed in great numbers in the river from the quantity of small ones about two inches long that are constantly brought on shore when drawing the net for grey mullet."

There can be little doubt that the superior size of all soles, as in other fishes, depends on a suitable locality where there is abundance of food easily obtained; much also depends on the climate; soles are not tolerant of severe cold; the further one goes north the less abundant and smaller in length and thickness they become; they find a more congenial home in the waters of the Mediterranean than in the Scandinavian seas; but suitable food is almost of more importance even than temperature; soles taken from clean sand, where there is no mud and where all animal and vegetable life is scant, do not grow to any size, nor have they the same flavour as those which live in ground where there is mud and rubble and a locality favourable for the development of animal and vegetal organisms. A case in point is, I think, to be found in another species of sole—the lemon sole, *Solea aurantiaca* of Günther. This fish must not be confounded with the so-called "lemon-sole" of our markets, which is not a sole but a species of dab, and which belongs to a different genus, viz. *Pleuronectes.*

The lemon sole is known to the fishermen of Devonshire as the "sand sole," and is occasionally brought into the markets at Plymouth and Brixham. This species is generally found in deep water, and does not occur near estuaries, and never ascends rivers; its peculiar colour, which simulates the clean sandy bottom on which it rests, bespeaks the nature of its habitat. Many kinds of fish, especially flat fish, whose resting-places are at the bottom, are known to assume the colour of the ground on which they are found ; a dark coloured sole, if it were placed on clean gravel or sand, would soon represent in its coloration the complexion of the sand or gravel, simulating sometimes the pattern so admirably as to deceive spectators, who may pass a tank with several fishes at the bottom, without being aware of their existence unless he look closely or the fish stir. Soles of different colours are not unknown : thus we have " shrub " soles, from the dendritic shrub-like markings on the back, " spotted " soles : and even the term " lemon sole " is sometimes thus applied to our common species ; but it is not usual to see soles of any other than the ordinary dark colour, if they have been taken out of the sea, and have not been kept in an aquarium. Pure arenaceous silex can nourish no form of animal life ; and if a sandy bottom be deficient in mud, animal life of all kinds will be scant there, and those forms of life which do exist there will have to swallow very large quantities of the sand in order to find nutriment from it, as may be seen by noticing the contents of some of the stomachs of *Echinoderms.* The lemon sole is found nearly always on clean sandy bottoms ; and its flesh is very inferior to that of the common sole, for it is soft and insipid compared with it. I may appear to dwell long, perhaps, on the question of food, but I do so designedly, because on it depends almost all other questions relating to fishes, and because it has a special bearing on the question of the artificial cultivation of the sole.

I have mentioned the lemon sole (*Solea aurantiaca; lascaris* of Day); it is at once distinguishable from the common sole, with which however it is occasionally sold, by its yellowish sandy or cinnamon colour. It is, however, a rare species on our coasts; though I have been in the habit of attending fish markets and looking into fishmongers' shops for many years, and have seen many fish of various kinds caught, I have only met with the lemon sole once, and this was at Torquay last year. Colour is not always a safe guide in determining a species, indeed it would be generally a most fallacious one—nevertheless in this case the colour of the lemon sole would nearly always bespeak its species; it has moreover certain structural characters which distinguish it from the common sole when of a yellowish colour, one of the most obvious of which is the large circular nostril on the blind side, which is surrounded by short but conspicuous filaments. Admirable figures of this species and of the other British species of soles will be found in Mr. Day's valuable work on *The Fishes of Great Britain and Ireland* now in course of publication.

Another species of sole, the variegated sole (*Solea variegata*), deserves especial mention from its excellence as an article of diet. I do not think I could distinguish in taste between this species and our common one; it is firm and of very good flavour. Great numbers of this fish are taken by the trawl at Plymouth and Brixham, where it is popularly known as the "thick-back," from its depth of body; it is a small species, of about six to eight or nine inches in length, and is consumed largely in Devonshire and Cornwall by the people there, who are well aware of its excellence; but it has only a local value, and seldom finds its way to London and to the markets in the interior of the country. This fish deserves to be better known. I do not know whether it is tenacious of life, like the common species; if it were, it might be desirable to transfer it to other waters around our coast. When I was in Plymouth in October 1882, I was asked sixpence for four of these fish, and at that price one could have a delicious repast at a trifling expense. Mr. Dunn records in Day's work the capture of several hundreds at Plymouth in the month of February; they averaged six to the pound, and "were being sold in pads, separated from the other soles, as offal." At Weymouth they are called "bastard soles." The variegated sole is of a brownish-grey or chesnut brown, with dark cross-bands on the body and fins, and is a very handsome fish.

A fourth species of sole completes the British list of the genus *Solea*, it is the *S. minuta* of Günther, the *S. lutea* of Day, and the "solenette" or "little sole" of Yarrell and Couch. This species is very small, and of no commercial value whatever; its usual size is about four inches. It is known to fishermen by the name of the "little sole" or "red sole," as it has often a reddish tinge about it. I have seen immense numbers of this little fish taken in the trawl in Torbay, and have also captured in a shrimp-net off Southport great numbers of this same species. I mention it here because I think it quite probable that this fish is not discriminated by some persons who find such grievous fault with shrimpers and others whose small meshes must capture large numbers of fish-fry, and that very frequently the small soles thus taken are not the young of the common sole, but of the *Solea minuta.* I do not deny that the young sole proper is taken by the shrimp-nets, and often in considerable numbers, but where I have seen half-a-dozen true soles I have seen scores of the "little sole" thus captured. The solenette is of a dark greyish or reddish colour, with numerous darker spots on the body, which spots are sometimes absent. The dorsal and anal fins have some of their rays at intervals black or dark, and though the reddish coloured ones are readily known from the common sole, this is not the case on a cursory inspection with the brown individuals. I suspect that this little species is common on various parts of our coast, where the bottom is more or less sandy. Its food, like that of the young sole, consists of small *entomostraca* and particles of mud mixed with sand; and in a specimen I have under the microscope as I write, I find the acicular spicula mixed with the sarcode of some sponge. Another question proposed for consideration is—

Are there sufficient reasons to believe that the natural supply of soles is gradually becoming less, and, if so, is this alleged diminution due to over-fishing?

The evidence which I have been able to obtain on this matter is conflicting; some persons, chiefly the fish-dealers, have no hesitation in saying that the supply of soles is annually becoming scarcer and scarcer; others again, chiefly the fishermen, have told me that they do not consider any diminution is going on with respect to these fish, that their capture is and always has been uncertain, that they are convinced there are as many soles in the sea as ever there were; "but," say they, "we cannot always drop across them;" and it is rare that they take them in sufficient numbers to meet the demand. That soles are fearfully dear is a very lamentable fact for the consumer, but their dearness does not imply any diminution of the natural supply—it only proves the existence of a demand which is in excess of the supply. According to the report of the Sea Fisheries Commission in 1865, soles in the Manchester market were selling at 3*d.* to 4*d.* per pound in 1856; in 1857 they were 6*d.* to 8*d.*; in 1859, 6*d.* to 10*d.*; in 1860, 4*d.* to 6*d.*; in 1861–2, 6*d.* to 8*d.*; in 1863 and 1864, 8*d.* to 10*d.*; in 1865, 6*d.* to 8*d.*; and now soles can rarely be brought at 1*s.* per pound—more generally they are 1*s.* 6*d.*, 1*s.* 8*d.*, 2*s.*, and even 2*s.* 6*d.* per pound. The demand for this favourite fish increases as the population increases. Railways have been largely instrumental in increasing the demand, as soles, with other fish, can now be conveyed from one end of the land to the other in a perfectly fresh state, which was not the case many years ago. However, our question does not directly bear upon that of price, but upon that of the natural supplies of the sea. Are soles diminishing in numbers around our coasts; are fewer caught now than in former years? It is not possible to answer this question, because we want published statistics from every trawling station on our coast, giving the daily capture of soles throughout the whole year, and no such statistics exist. Were we in possession of such statistics year by year, then, and then only, could we be in a position to say whether diminution is going on or not. If fewer soles are caught now generally all round our coasts with increased and more effectual appliances for capturing them, there must be a scarcer supply in those waters where they were formerly caught abundantly.

An East Coast fisherman writes in Mr. Day's last number of his work on fishing:—

"It is well known among fishermen that there is a falling off in the supply of soles and plaice to an alarming extent whatever may have been said to the contrary by smack, owners and fish-salesmen. To explain this I shall have to carry you back to the time when we first went to fish off the Sylt, about ten years ago, at which time very nearly all the ground from Horn Reef to Heligoland was covered, as it were, with shoals of small plaice, and intermixed with these plaice were a good many soles, both large and small. We have got as many as eighty baskets of small plaice and ten baskets of soles for one night when we first went there, and very nearly all the plaice would be thrown overboard; and you may be aware that they always die after they have been once on board a trawler. These fish are so small that I have counted two hundred and fifty in one basket such as we use at Grimsby. The small plaice that are brought to the London market are the largest picked out, and then the others are thrown away. Now we have fished there every summer, heaving big bags of small plaice on board, and throwing them away for the sake of the soles, till, by destroying the young brood, full-grown plaice have become very scarce. At the present time very small plaice will sell well, so that, now the soles have grown scarce off the Sylt, the small plaice, being saleable, make up; so you see they are bound to be caught unless stringent measures are taken for their preservation. You must remember that the quantity has decreased during these last few years, twenty baskets being the most you would get for a night now. My opinion of the matter is this, that as the ground from Horn Reef to Langerorg, within a less depth of twelve fathoms, is a natural nursery for young brood; if the wanton destruction of it continues as it has done, we shall soon find it extremely difficult to find even a moderate supply of full-grown plaice, but, if stopped, I have no doubt that both they and soles would be more plentiful. It is to the interest and benefit of every one in the fish trade that no

English trawlers should be permitted to fish within the above depth."

Mr. Mann, writing from Bournemouth to the *Field* in April 1882, says: "I have just weighed a sole of one ounce and a turbot of four ounces, which were exposed for sale here. They were selected from many others of like size. Sixteen pounds' weight were captured on one occasion, the largest not exceeding eight ounces. The bulk were taken in bag-shore nets, known as tucks, of small mesh, from which nothing can escape; but this form of net does not kill the fish, which ought to be at once returned to its native element." Mr. Day himself says: "It has again and again been brought prominently to notice, especially about the fishing-grounds of the North Sea, that the supply of soles taken in British waters is yearly decreasing, as evidenced by the trawlers having to go farther out to sea, that an increased number of vessels capture only an amount similar to what formerly were obtained by fewer boats manned with less hands, and likewise that the fish supplied to the markets consists of such as are smaller than used to be the case. Mr. E. Jex, of Billingsgate, remarked (January 7th, 1882): "There have been during the past year some thousands of boxes of soles in this market from Yarmouth, Lowestoft, and Ramsgate; while not more than one-fourth of the contents of each box consisted of fish that ought to have been caught, three-fourths of each box nothing but slips and tongues. When at Weston-super-Mare in 1879, some new trawling ground was tried, and the large size and quantity of these fishes that were taken amply recompensed the trawlers. But such localities are often over-fished, and soon become exhausted, and thus quantity has to be made up by those of smaller size. This is possibly what is found to occur in most places. Thus Mr. Dunn observes that his father was the first fisherman who employed a beam-trawl in Mevagissey Bay; he captured enormous numbers of fish, so much so that he kept a record, which unfortunately has been lost. When the Plymouth trawlers first commenced their operations in new localities off the south-west coast (which was about the time the Californian gold-fields were discovered) they termed their new grounds 'California,' as illustrating the amount and value of their captures. It has been pointed out, by Mr. Epton and others, that a large fleet of smacks towing over the same ground will in a short time clear off the fish which are there. But the main cause of the diminution in the North Sea is generally asserted to be due to the numbers of undersized fish which are wantonly destroyed in shallow waters or their natural brood grounds by trawling smacks, steam trawlers, and shrimp-catchers, more especially by smacks along the German coast during the spring and summer months." ('The Fishes of Great Britain and Ireland,' pt. v., pp. 37, 38.)

Dr. Beverly R. Morris, whose name is known to naturalists by various zoological works, has written a letter in *Land and Water* (October 3, 1868) on the "Destruction of the Fry of Sole in Bridgewater Bay." He says: "Bridgewater Bay is the estuary of the river Parret, which flows into the British Channel about thirty miles below Bristol. The extent of the bay from north to south is about ten miles, its depth [width] about five miles. If a chart of the British Channel is examined, it will be seen that the whole of the ground within these limits is a succession of mud or sand flats, with a moderate depth of water; and it is probable that there are few localities of equal extent which offer such a promise of abundant supply of flat fish, especially soles, and yet the actual take of these excellent fish is very trifling, and the fish taken are generally of small size, though of admirable quality and flavour. A full-size sole is a rarity, and we have to depend for soles of a fair size upon the South Coast fisheries, from whence a considerable supply is derived. The question naturally suggests itself, why is this? Why do not the soles in Bridgewater Bay attain the normal weight and size? This might have been a difficult question to solve; it is, however, too easily answered. The young fish is largely destroyed by the fishermen of this district. To explain this suicidal act of theirs, I must mention that almost the whole of them engage largely in the shrimp-fishery; in the prosecution of this, circular nets, ending in a pocket, called hose-nets, are fixed to stakes in the tide-way, and at low water are mostly high and dry, and whatever is in the pocket dies. These nets are left for two, and sometimes more, tides if the weather is bad, and it is not likely that anything is alive, unless perhaps some of those captured during the last tide. The bulk of the contents are shrimps, but besides these a very large number of small fry, chiefly soles and flounders, are also taken, these, being useless, are thrown on one side. Some bring them ashore, but most of the men throw them overboard. It is difficult to come at the actual amount of the young fry (generally from one to two inches long) thus destroyed, but I have heard it estimated by competent people at (if allowed to come to reasonable maturity, say from six to ten inches long), from five to eight hundred tons annually of soles alone. That such a wholesale destruction of one of our best and most nutritious fishes should be continued is a matter of very serious moment; and I trust the Government may be induced to take some decided steps with a view to legislation upon this very important matter. It seems a great pity, and indeed a disgrace to the district, that we should be dependent on the South Coast chiefly for a supply of fish, when we have at our very doors a fishing district second to none in England, as I believe, for the growth and capture of flat fish. That a paltry fishery for shrimps should be permitted to interfere with such a valuable one for soles, &c., as I am confident could be easily developed here, is a matter of deep regret, and no reasonable effort should be omitted to alter such a state of things. Some of the fishermen set as many as eighty of those hose-nets, and the constant destruction of young fry can readily be imagined. Surely some other way may be devised for taking shrimps which could not be injurious to the sole fry, and probably equally remunerative to the fishermen."

The late Mr. Frank Buckland says: "Great destruction of small soles takes place by in-shore trawling in the spring months—a matter that demands the interference of the legislature. Mr. J. L. Sealy, writing from Bridgewater, April 12, 1869, speaks of the enormous waste of fish food by the destruction of young fry. As much as eighteen cwt. of the fry of soles, plaice, herring, whiting, &c., is calculated as having been destroyed in one day."

That the destruction of young fry of various kinds of fishes is very great, there can be no reasonable doubt; and soles are not exempt from suffering in this respect. Certain statements however, such as that of Mr. Epton "that a large fleet of smacks towing over the same ground will in a short time clear off the fish which are there," must, I think, with all due respect to him, be taken *cum grano salis.* Man's destructive agency in a limited area may do, and often does, much injury; but in the wide expanse of the North Sea one cannot possibly imagine that much, if any, appreciable work of diminution goes on. The trawlers at Grimsby, though the fleet is, I believe, between 700 and 800 vessels, are widely separated; it is seldom they come near together; often many miles separate them. When I was trawling in the North Sea, in July 1882, I thought it quite a novelty in the wide abyss of waters to come near a smack at all; and when we consider the vast area of ground and the comparatively small area trawled over, there must be an abundance of fish life which is never disturbed at all, or at any rate but seldom. Take Torbay, a limited area—for a long time, year after year, have the trawlers worked there; and, if over-fishing could cause a diminution in the quantity of soles, it certainly might be expected to do so there; but, from what I could learn from the fishermen, there is no diminution; catches are confessedly uncertain; soles are erratic in their movements; the weather the last few years has been stormy, and soles have not been brought to the market in abundance sufficient to meet the demand.

With respect to the waste of young sole life in the shallower waters, all that can be said is this. It seems a pity that there should be such waste; waste in anything is a thing to be discountenanced; but waste, as we usually interpret the term, occurs in nature a thousand times more than it does by any destructive agency wrought by human hands. A storm will cast up on the shore the floating eggs of fishes, and strand them there to perish in millions; young fry are left on the beach by the retiring tide, and a hot sun kills millions in the shallow waters in an hour or two, but there is always a residue left from the shallow waters which survives and goes into deeper waters, there again to encounter in their various stages of existence the numerous enemies, whether mammal, bird, or fish, which they are sure to meet with; but even here a large percentage remains to grow up to sexually mature forms, and deposit their spawn in the shallow waters; and these again have to go through the same beneficial process of being thinned by various forces, whether living or cosmical, once more to leave a surviving progeny, destined to populate the widest areas. But it may be asked : if all this be true, what is the use of taking a lot of little fishes which are not of the smallest value—why not leave them to grow? The answer is a simple one. If by legislative interference we put a stop to catching the small fry of soles or of other fishes, we must also put a stop to the capture of a large number of adult fishes, of various species, which form part of the staple of general fish-supply ; and the result will be a diminution of fish-food in our markets, or an interference with other most important fishing business, as for instance the capture of shrimps, which requires a small mesh. Dr. Beverly Morris contrasts what he is pleased to call "the paltry fishery for shrimps" with the valuable one for soles. Is Dr. Morris unaware that the shrimp fishery is one of great magnitude, that it gives employment to hundreds of honest men, upon whose labours depends their daily bread, and the source of much excellent food to the people? Such an expression as "the paltry fishery for shrimps" must be passed over without further comment. If we cannot have soles except at the sacrifice of the real interests of others ; if we cannot add to the luxuries of the wealthy classes or to the pockets of our fishmongers except by detracting from the necessities of a class of hard-working fishermen, then *pereant soleæ, fiat justitia.* If it were possible to preserve our young soles on the shallows without injuring the callings of any class, by all means let us do so; but practically this does not seem possible. "The produce of the sea is the property of the people in common," as the Commissioners in their Report truly and wisely say, and we ought to be jealous of any unjust interference. Let us consider for a moment what would be the result of stopping trawling for two or three months in water of a less depth than twelve fathoms. Such water, where young fish are collected in great numbers, is at times tenanted by large numbers of predaceous fishes, especially haddock, which come to feed on the smaller fishes ; cod, ling, coal-fish, skate, hake, and other carnivorous fishes would have the work of destruction all to themselves unmolested, for half-grown specimens of many predaceous fishes are found in a less depth than twelve fathoms ; and all these fish, which are very important commercially, would be disporting themselves in the water instead of supplying us with food. Mr. Day says any prohibition against the capture of soles under a certain size would make penal the capture of the little sole (*Solea minuta*), and he asks : "If these small forms alone are permitted to increase, what will be the effect on the food of the *Pleuronectidæ* generally? For, should the useless forms be protected, and if they live on the same diet as the useful table-sole, it appears as if such legislation might cause more injury than benefit to the fisheries." I cannot attach any force to this argument, because I do not believe that any amount of catching this kind of fish or that kind will have the slightest effect, in wide sea areas, of causing any appreciable difference in the number of fishes or in their natural food supply. These comparatively shallow waters are very productive of fish, because there is more abundance of food there ; as the fish grow larger they wander far and wide into deeper water, and if we want to catch them we must go after them, and pursue them, as big fishes pursue little ones. It is of course possible, as before said, to cause diminution of soles and other fishes within limited areas by over-fishing, and if any mode of protecting the natural nurseries can be suggested that would not work injuriously to the interests of certain classes of fishermen, and would not curtail our market supplies, it is both our duty and interest to afford such protection; but the destructive agency of fishing has no appreciable effect on the number, distribution, and food-supply of fishes in an almost unlimited area, such as the North Sea.* Professor Mobius, in his excellent Paper on the Food of Marine Animals ('Report of the U.S. Commission of Fish and Fisheries,' Washington, 1882), has well said: "In no part of the sea has fish-food decreased, as has been the case in many fresh waters of highly cultivated countries, causing a decrease of fresh-water fish. In many countries our modern civilisation has destroyed the *natural communities* (cenobitisms) of plants and animals, and substituted those plants and animals which were most profitable to man. But the natural communities of the sea human agencies can only change to a certain degree in the coast waters. In the open sea the natural communities of plants and animals will continue to live and sustain each other as long as the waves of the eternal ocean continue to roll."

The same complaints about the diminution of soles and other fishes by over-fishing, or by fishing on grounds which, as it was said, ought not to be fished at all at certain periods of the year, which are constantly made now, were made in 1863 and long before that time, and if any one who remains sceptical as to the validity of those complaints, would carefully read, mark, and inwardly digest the whole subject, so admirably, so forcibly, and so fairly discussed in the Commissioners' Report already alluded to, I think he would find it extremely difficult to refuse to attach the greatest weight to the evidence, and the conclusions based upon that most voluminous evidence, there brought so plainly forward. The daily demand for fish by the increased and ever-increasing population is almost unremitting, the daily supply is fluctuating, owing to various causes —especially, the last few years past, to the storms which on all parts of our coast have been so lamentably and destructively prevalent. In calm weather, again, though the sea may be especially productive in any given area, the supply of fish caught is often small comparatively, because the smacks have not sufficient wind to convey them to the fishing grounds, and to work the trawl when arrived there.* Moreover, after long-continued calm weather, the sea water is clear, and the fish get out of the way of the trawl. Could we always secure the best kind of weather for trawling purposes, the captures would always be great, and sometimes enormous. In the *Daily Telegraph* of April 26th, there is a paragraph headed: "Great Catch of Fish." It states that an almost unprecedented catch of fish was landed at Scarborough on the 25th. During the morning tide ten smack trawlers and one steam trawler arrived, having an average catch of 100 boxes each, or about 1100 in all. Each of these boxes, being level filled, will weigh about four and a-half stones, so that there would be landed 4950 stones weight of fish. The latter was of varied character, and sold cheap, although there was good demand. Soles were sold at about *1s. 4d.* per pound—we are not told whether the catch of soles was proportionately great; but they are always in demand, and always fetch a high price. Now it is certain that at this time of the year (end of April), soles are far from being in their best condition; they have not recovered from spawning; and soles, like nearly all fishes, do not eat at this time; their flesh becomes to some extent watery and soft; but in the eyes of the public a sole is a sole at all times of the year, and equally good. If people were wiser they would refuse to pay an exorbitant sum for a fish which at this time of the year is neither nutritious nor of much flavour. But custom and fashion rule dominant, even in matters relating to a fish diet. Codfish, which spawn early, have quite recovered by July, and are fat and in excellent condition at that time; but fashion says oysters are not yet ready, and so fresh cod is out of season in the aristocratic world of London and elsewhere. So fresh codfish is but little consumed; and the great quantities caught are salted and sent to foreign markets.* It is time to say a few words on the third question proposed.

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* "The well-known fishing grounds in the North Sea," as the Sea Fisheries Commissioners remark, "are even yet only partially fished. The Dogger Bank, which has an area of several hundred square miles, and is most prolific of fish, is to a great extent unworked by the trawlers, and new grounds are still being discovered where fish are found in great abundance. Between England and the Continent the average depth of the German Ocean is ninety feet. One-fifth of it is occupied by banks which are always being added to by the muddy deposits of the rivers of both countries. In extent they are equal to the superficial area of Ireland. To these banks the animals of the ocean chiefly resort, and this great and prolific field is free to the industry of all." (Report, p. xvii.)

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* The want of more steam-trawlers, either to act as carriers from the smacks or to fish themselves, is becoming more apparent.

CAN THE SOLE BE ARTIFICALLY CULTIVATED?

There is an old saying that what has been done before can be done again; and soles have been kept alive in salt-water ponds, where they have grown and thriven; they have also done well in fresh water. The ancient Romans kept soles, with other species of fishes, in their vivaria; Dr.

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* Of course in the hot weather the necessity of salting the larger proportion of codfish is apparent. I am only speaking of the general opinion that the codfish is not at that time of the year eatable.

Badham, in his interesting book, 'Prose Halieutics, or Ancient and Modern Fish Tattle,' has given us a very good account of these vivaria of the ancient Romans, which I will now transcribe. I should mention that Varro (born B.C. 116) and Columella (a contemporary of Seneca, who lived at the early part of the first century of the Christian era) are the chief authorities on these Roman vivaria, though frequent mention occurs of them in the writings of Cicero, Horace, Martial and others. Columella enters much more into particulars than Varro, and gives us directions as to where and how to construct proper marine fish-ponds. "He particularly recommends them in insular situations where the soil is poor, and the returns small or none; in such situations they may be made to turn to excellent account. Mere sterility, however, ought not to be the only consideration in determining the site of a sea-pond; several other things, as we shall presently see, should also enter into the account, but, when these are present, the best place to commence operations is so near the sea that its waters may easily wash through, and never stagnate, thus imitating the great main whence they are derived, which, never being of the same temperature, is in perpetual motion, and renewed every hour! They may be made of tiles, 'opus signinum,' or be excavated in the solid rock; in either case, in all such ponds as are not perpetually motionless and asleep, that extremity which lies furthest from the sea, and is deeper and cooler than the other, should conduct by straight or tortuous channels into a grotto where the scaly troop may retire from the heat of the day, like cattle, for refreshment and cover. The watery alleys leading to these places of repose should not be too broad for *Murenæ*, which prefer a narrow nestling trough; some, however, object altogether to mixing *Murenæ* with other stock, as they are liable *to go mad, like* *dogs*, and in that case will bite, run down and destroy every other species shut up in the same reservoir, till they have entirely consumed them. In feeding these reservoirs the supplies of water should be let in from one side, and the issue, if possible, be made to take place at the one opposite; this will secure a perpetual renewal of the water, which is a matter of prime importance here; a convenient coolness being also of equal consequence for the salubrity of the fish, the deeper the source whence the sea water is procured, the better; and, whenever it is practicable, the pond should fill itself from below. When the vivarium to be formed is scarcely above the level of the sea, its basin should be dug out about nine feet, and the conduit pipes placed about two feet from the top; they should be as capacious as possible, to admit sudden flushes of water, which will help the issue of the stagnant mass lying below the sea's level . . . . In providing for the issue of the water from the pond, the exundation is best effected by means of a brass grating, with apertures of a size sufficiently great to let it run freely out, but too small to allow the escape of the young fish. If the dimensions of the pond permit, it is no bad practice to remove fragments of rock, covered with seaweed, from the neighbouring shore, and to scatter them here and there in these little enclosures, in imitation of the open sea. As the *gîtes* of the fish are very various, some lying on a bed of sand, some ambushed in mud, others feeding among rocks, your pond should be constructed according to the character of the sea in the neighbourhood; and, finally, when the work is completed, a series of stakes should be planted in a semi-circular form round that part of it which lets in the water. These must be placed above the level of the waves so closely as to break the force of the infringing waters, and to keep out the wrack and weeds which would soon else fill the piscina. Having thus constructed and secured the pond against casualties, the next point should be to stock it wisely, for as on land all fields will not bear the same crops, just so is it in the vast acreage of waters; we must not think, for instance, because we find inexhaustible supplies and multiplication of mullet [red mullet] at large in the open sea, that we shall therefore succeed with them in a pond; on making the experiment, we shall have the mortification to learn that rarely one or two out of many thousands of these delicate fish will bear a pond life. So too there is little use imprisoning fine exotic fish, whose requirements are not well understood. Such stock may live indeed, but they will not multiply, and so are without profit. Sluggish mugils [grey mullet] and the voracious lupus [basse] should be selected as easy to rear, as also turdi [perhaps wrasse], and other saxatile fish of value. In regard to poor fish, we make," says Columella, "no mention of them, since they are neither worth the capture nor rearing; but, as all good fish do not thrive on the same bottom, study that which is prevalent along your own shore, and according as it is stony, sandy or muddy, do you imitate these same peculiarities in your stew. An oozy bottom does best for flat fish, as soles, turbots and plaice; such a pond, too, is the best nidus for all kinds of coquillages, oysters, scallops, &c. A sandy bottom, though not absolutely bad for flat fish, suits the open sea fish best, such as auratas, the dentex, and Punic and indigenous umbras; while it is less congenial to the growth of shell-fish." Columella tells us that it was customary to bring fish from the sea, and turn them into lakes; and he mentions the names of several persons who had succeeded in their experiments.

I have already mentioned that soles are fond of frequenting rivers, which they ascend for the distance of several miles; it is also asserted that they breed in the river Arun. Yarrell quotes from McCulloch as stating that soles have been kept in Mr. Arnold's pond at Guernsey, and that they grew there in thickness twice that of fish of the same length in the sea. More experiments are required to satisfy us that the sole would thrive well in water which is entirely out of the reach of the tide, but there is strong reason to believe that it would grow and do well in fresh water. First of all, there would not be much difficulty about that all-important matter, the question of food; the sole requires mud mixed with sand, into which in the severe weather it can bury itself, and from which it can derive living or decomposed particles of organic matter to nourish it.

In the sea the sole feeds largely on worms of various kinds, bivalve molluscs, small fishes and crustacea. Most of these it could readily obtain in ponds and rivers. The larvæ of different kinds of insects, as *Ephemera*, *Baetis*, *Sialis*, the *Phryganidæ*, *Dyticus*, &c., fresh-water ponds could supply; crustacea, however, it would not be able to obtain in anything like the quantity or diversity that it is able to do in the sea. Numerous species of *Entomostraca* in weedy ponds, however, would not generally fail it; *gammarus* and *asellus* would be obtainable; bivalve molluscs, as *cyclas*, *planorbis*, small *limnei*, are generally abundant in all ponds. But I believe that the larger percentage of food the sole would obtain from the minute particles of living or decomposed matter contained in the bottom of the water. The ancient Romans fed the soles in their vivaria on various things. Columella says that flat fishes (*pisces jacentes*) require softer food than those which dwell near rocks, because they are either without teeth, and suck in their food, or swallow it entire. "Therefore," he says, "you should offer them bits of salt fish, the gills and intestines of fishes—in fact any kind of salted refuse swept from the fishmongers' shops." He also says it was usual to give soles, turbot, and brill, green figs which had been opened, broken bits of the arbutus, and the crushed fruit of the sorbus (*Pyrus domestica*). It would be curious to ascertain how far salt fish and fruit would agree with and nourish soles; experience would decide what kinds of food are most suited to it. There would be no difficulty in transferring young soles from the sea to a long distance inland, for they are tenacious of life. I do not know whether the ova have ever been taken from any of the flat fishes and artificially impregnated; most of the fish which have been thus treated are the cod, the Spanish mackerel (*Cybium*, not *Scomber*), and the black and striped basse of the American waters, the American shad, and the herring. It is indeed not a common thing to find a sole with milt or soft roe inside it; the soles which come to our tables with roe nearly always have it hard, and I never remember eating a soft-roed sole. However, store soles are to be had abundantly on nearly all of our sandy shores, and the net of the shrimper will secure them quite uninjured.

It is doubtful whether the sole would bear a transference from its sea-water habitation to a fresh-water one, if suddenly made; those individuals which are found far up in our rivers have for a time sojourned in brackish waters, and so have gradually become accustomed to fresh water. It is true that some fishes are equally tolerant of fresh water and salt, as the eel, the salmon, the grey mullet, and the basse; a sudden change from the salt to the fresh, or *vice versâ* seems in no way to affect them.

It certainly does seem desirable, as I think it is practicable, to utilise the quantity of sole life which is taken in the shrimpers' or the stow-boats nets, and to turn the little fishes into some suitable reservoir of salt water near the sea, where fresh flushes of water could be conducted by means of pipes. In fact there is no natural history reason why fish-cultivators should not revive the old Roman custom of open vivaria, such as those spoken of by Columella and Varro.

Amongst the classic people of ancient Rome there were some among the rich who kept and stocked vivaria merely for amusement, and who lavished untold sums of money upon their construction and their inmates. With these *beati piscinarii*, "blessed fish-pond men," of whom Cicero in one of his letters contemptuously speaks, vivaria were a mania; the fishes were sacred pets, and no one ever thought of "summoning them to the dining-table."* Such a man was Hortensius, of whom Varro says that he was not only never entertained by his fish at table, but was never happy unless he was entertaining and fattening them. But the vivaria occupation was regarded generally as a trade business. Columella says that this fish-culture was not to be looked upon as a mere common affair, but as one especially praiseworthy and honourable; and he considers that, when properly conducted, such an occupation would be a source of profit to families. "For he who has bought islands or land near the sea, and cannot derive any profit from the fruits of earth on account of the sterility of the soil near the sea, may make his profit from the sea." He also gives advice to feed the fishes well, and not do like some mistaken people, give them nothing to eat, "because when you take your fish to market, its leanness will proclaim it a vivarium fish, and not one taken from the open sea."

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* "Convocandi ad jus," says Varro, with an attempt at a pun. *Jus*, besides "law," means "fish-sauce."

The cost, however, of constructing such reservoirs would doubtless be considerable, and the care and management necessary to ensure success would certainly not be without other attendant expenses, and in a commercial point of view I should imagine very few people would care to embark in such a scheme; but as the means of carrying on scientific researches and experiments into the natural history of the sole and many other valuable food-fishes, such vivaria would prove an inestimable boon. It will be for the Piscicultural Company, lately formed under promising auspices in London, to consider how far such a system as that alluded to is practicable and likely to meet with success.

Soles are dear; they are not at present caught in sufficient numbers and sufficiently continuously from day to day to meet the enormous demand for them, and if we wish to increase the number of soles in our markets we must multiply our fishing-boats and fishing gear, and occupy our business over a greater area of water; and, above all, so far as London is concerned, the monopoly of one crowded market must come to an end, and local markets must be multiplied in the metropolis, so that with increased means of capture, combined with greater facilities for the reception and distribution of our sea fishery, the consumer will have a chance of obtaining such food at a far less cost than at present.

OYSTER CULTURE.

"NIL DESPERANDUM"

"Quomodo vivent Ostreæ, nostri est farrago libelli."

"To show how Oysters breed, grow, live and die;
We can't command success. But still, we'll try."

[COMMANDER C. V. ANSON, R.N., AND E. H. WILLETT, F.S.A.]

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INTRODUCTION.

NEARLY all men and women are naturally fond of oysters; if not always, "nearly" always. The physician frequently prescribes a few oysters to his patient after a severe illness, for they can be eaten and digested when our proud interior organs refuse other aliment. Why?

The reason is that they are very nourishing, and supply a want that is felt more and more in these days of severe competition. To persons who follow sedentary or literary pursuits, the necessary phosphorus that adds so much to their nerve and brain power can be taken in a more concise and palatable form by swallowing a dozen oysters than by eating a much larger quantity of more cumbersome food.

Oysters contain chlorides of soda and magnesia, sulphates of lime and magnesia, and, last but not least, a good deal of the phosphates of iron and lime.

The gelatine and mucus render them very digestible, and the animal material is worth many times its weight in essence of beef.

Public attention has recently been called to the defective state of the arrangements for supplying the metropolis and the country at large, with fish of all kinds, and the "Fish Culture Association" has been started under influential patronage to rectify this state of things.

Other countries have led the way in the direction of fish culture generally, and oyster culture in particular, and great support has been given by some foreign Governments to this work. Up to the present time but little has been done in England to remove the prejudice and to enlighten the ignorance of the fisherman, and still less to prevent the enormous waste of fish that annually takes place.

We therefore hail the Great International Fishery Exhibition as the advent of a new era for fisheries of all kinds. Before long we hope to see all the most valuable fishes cultivated by man in the like manner that plants, vegetables and animals have already become subject to his selecting culture and care. By this Exhibition an impetus will be given to the artificial cultivation of oysters and other shell-fish, and valuable foreign fishes at present unknown in England may be introduced to the benefit of the commerce and health of all nations.

A treatise on oyster culture would be incomplete without some reference to *Sergius Orata*, and we must therefore follow in former footsteps, or "sheep walk," as Sydney Smith called it, by briefly referring to the ancient epicure, who, the elder Pliny tells us, "first conceived the idea of planting oysters in beds."

The scene of his operations was the Lucrine Lake, where he had large tanks made to store his oysters, brought, some of them, we are not told how, from England's shores; close to his oyster tanks he is said to have built a palace, so as to be able to consume his favourite bivalves in incredible numbers with convivial friends at all hours of the day and night.

Near the Lucrine Lake is another sheet of water, Lake Fusaro, where the industry of oyster growing has flourished for a period of 2000 years. This lake, which is supposed to be the Avernus of Virgil, is a quiet dark pool, about a mile in width, of volcanic origin.

It is here that M. Coste first saw the practices in vogue for oyster breeding, which he subsequently introduced along the coasts of France.

Great efforts have been made in France since that time to promote the production of oysters by artificial means, and protective legislation has been freely enforced for the preservation of public grounds, as well as for the encouragement of private enterprise.

M. Hyacinthe Le Boeuf has the credit of having given a start to artificial cultivation in 1848, by the construction of parcs at the Ile de Ré, but his system was only a modification of a plan that appears to have been in vogue at the Ile d'Oléron for upwards of sixty years. In 1856 the French Government commenced its grants to M. Coste for the purpose of experiment along the Norman and Breton littoral.

For some years these experiments were continued successfully, but ultimately the fisheries at many of the localities, owing, it was said, to the improvidence of the owners and fishermen, had to be abandoned, for they had declined to such a state as not to be worth working.

Since then the French Government has bestowed unremitting attention to the subject, the result being that we are now principally dependent on France for our supply of young oysters for laying down to fatten.

It is wonderful how quickly oysters will fatten, and we believe that very often a fortnight will be sufficient to "plump" them up for the market, and also to partly acquire the flavour of any particular locality.

Oysters from L'Orient, Auray, and Arcachon, when in their second spring, are brought to Whitstable. If they have the benefit of a genial spring and warm summer, they grow and fatten sufficiently to be sold for consumption when the oyster season commences.

There are many other localities besides Whitstable where oysters could be easily fattened; those places, where the denuding influence of the water is being exerted on alluvial deposits, are most favourable. Because the industry has never been tried at any locality is no reason why of necessity it should not succeed there, as it must be recollected that an obstacle diverting a river current may cause a sand or mud bank to be deposited. A large fall of cliff may cause a variation in the angle of declivity of a beach. Either of these events will alter the mechanical composition of the water at the spot, and so in time change the character of the plants and animals found upon it.

The nature of the soil has so marked an influence upon the food, and subsequently on the appearance of living things, that fishermen can often identify individuals of the same species as coming from certain localities. This is even the case with such fish as turbot, soles, whiting, &c., and is much more marked in the case of oysters, which latter carry on their back their mark, as easily deciphered as pieces of Chelsea, Sèvres or Dresden china. The more nomadic the habits of the fish the more cosmopolitan are its characteristics; but the more stationary its habits the more easy is it to identify its origin. The salmon and the oyster may be taken as antitheses in this respect.

Before concluding our introductory remarks we will state the points about an oyster which it is desirable to cultivate. They are—

1. Flavour.
2. Shape.
3. Size and texture of shell.
4. Proportion of organic to inorganic matter.

The average proportion of meat to shell in different kinds of oysters was taken by the late Mr. Frank Buckland (to whose researches we must refer more than once in our essay, as he, of all men during his lifetime, was the keenest observer and the best authority on oysters), who found that in the best Whitstable Natives, out of 5 lbs. weight of unopened oysters there was 1 lb. of meat and 4 lbs. of shell. The proportions in Scotch, Arcachon, and Dutch oysters, that had been relaid on the Whitstable ground, were exactly the same. This should be an encouragement to our fatteners to import large quantities of foreign oysters when there has been a failure of spat on English grounds. The growth of the new shell is also remarkable, showing that the oyster, when relaid, has secreted the same substance for shell-making as a real Whitstable Native; we may therefore fairly assume that the fish itself becomes very nearly, if not quite, equal to the real Native.

The flesh or fish of a first-rate oyster should be quite firm, either white or of a delicate cream colour. It should taste all the better for being masticated, and leave as an after-taste an appetising, rather undescribable, kind of sensation in the mouth, which has been likened to that which a young fresh nut produces. The beard should be of a very light brown or sandy colour, except where it is coloured green, as in special localities. The better the oyster is "fished" the fuller it will be, and the cream-coloured part should extend everywhere, except over that portion which is exposed by the separation of the adductor muscle in opening the oyster.

The shell should be inclined to the left when the oyster is laid on the palm of the hand, with the flat shell downwards. Inside it should be of a clear opalescent character, something similar to delicately made white china. The

OYSTER CULTURE.

CHAPTER I.

NATURAL HISTORY.

Ostrea edulis is the Latin name for the common oyster of the present day. The American Blue Point and the Portuguese oyster belong to a different family, their generic name being *Gryphœa*. They are both molluscs, and are called *Lamelli-branchiata*, a name having reference to the delicate membraneous gills, commonly called the "beard."

As every one knows, there are two sides to an oyster; one is convex and the other nearly flat. They are closed by a strong adductor muscle, which is attached to both valves. They open by means of an elastic ligament, which is so disposed that when the valves are opened or closed it is either stretched or compressed. When the oyster dies or when the adductor muscle is severed, the shells immediately open, or "gape," as it is called.

An oyster on examination will be found to consist of two parts tolerably distinct from one another. They are—

1. The mantle or beard.
2. The body.

The former consists of a delicate fringe of membraneous fibres, divided into lobes with four similar striped leaves having radiating capillary tubes running throughout their substance. The mantle varies in colour from a very light greyish-brown to black, according to the variety of the oyster and the food upon which it has been living.

As a rough rule it may be stated that "the lighter the colour of the beard, the better the quality of the oyster." This however does not apply to green-bearded oysters, which are of exceptional character.

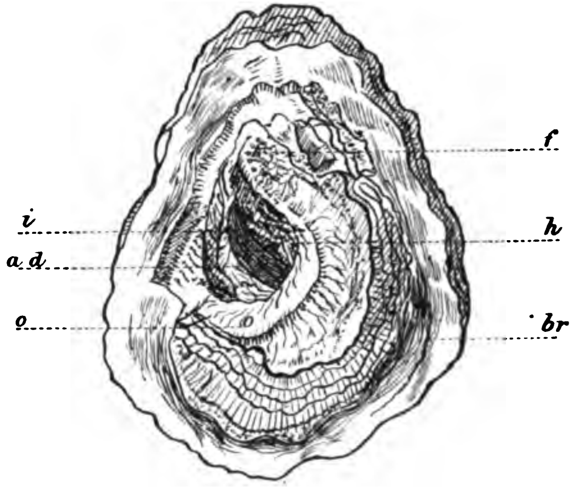
The beard is one of the most important organs that the oyster possesses, and many are the functions that it is called upon to perform. Primarily, it takes the place of the lungs in higher animals, the delicate tubes running through it favour the interchange of gases between the water and the colourless blood of the oyster, whereby the latter is oxygenated and animal life maintained.

In the next place the mantle serves the purpose of feeding, the gills acting like a rake in collecting the food and drawing it, by means of little hooks bent inwards, into the mouth of the stomach, where it is slowly crushed and consumed.

The gills are worked with a graceful fan-like motion similar to that observable in the dorsal fin of the hippocampus and pipe fish, which has not been inaptly compared to the motion of a field of corn when acted on by the wind.

Every filament of the branchial fringe, as the microscope will show, is covered with numberless *cilia* in constant vibration, causing, by their united strength, currents of water to be set in motion, which sweep the floating animalcules on which the oyster feeds over the mouth, whence they are caught and absorbed, the labial fringe having the power of rejecting unsuitable food. Were it not for this provision

PLAN OF AN OYSTER FROM NORTH SEA.



Upper Branchia	*br.*
Heart	*h.*
Intestines	*i.*
Ovaries	*o.*
Liver	*f.*
Adductor muscle	*a.d.*

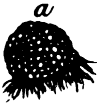
a

A

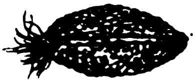
a

a. a. Spermatozoids.
A. Cluster of White Spat.

a


White Spat (magnified) without shell.

b


Black Spat (magnified) similarly

the oyster would soon find its supply of food become too circumscribed in still water.

We annex a rough sketch of an oyster. Behind the mantle, in that whitish part which we regard as the flesh, the intestines, ovaries, and liver are situated. The heart consists of two cavities resembling small round bladders, and is fed by the blood-vessels, which are but little ramified.

Owing to feeble organisation and low nervous power, the pulse is slow and weak. The convolutions of the intestines and the vent are situated near the right side of the adductor muscle, which communicates with the principal nervous centre, and also with the branchias, mantles, and sides of the labial orifice, where two small nervous centres are located.

Reproduction.

Professor Huxley, in his 'Anatomy of Invertebrata,' states that "in the common oyster the genital cœca in any given individual are found to be either almost all ovigerous, or almost all spermigerous, and it appears probable that the predominantly male precedes the predominantly female condition."

M. Coste, speaking of the reproduction of oysters, says that "the minutest researches show that, without any exception, there are to be found spermatozoids and eggs in the same organ, where they develop themselves side by side. The capsules (or sacs) in which the spermatozoids are formed arrive in the first place at maturity, and then the mobile small bodies destined to affect the fecundation are seen emerging from them when the ovules, or small eggs which they are to vivify, begin to make their appearance. These molluscs are consequently hermaphrodite. This is now an incontestable fact."

Oysters may therefore be considered as being of one sex, and producing eggs that are already alive, though until quite lately this has been disputed.

The most conclusive proof that fertilisation takes place within the parent shell, and without contact with any other agency, was that undertaken by the late Mr. Buckland.

Some of the spat from a white-sick oyster was placed in a test tube. It had been previously examined, and seen to be in the immature shell-less state which the product of white-sick oysters always shows under the microscope, and it was kept at a temperature of 68° Fahrenheit for several days. Gradually it passed through the yellow and slate-coloured stages that spat is known to undergo, and it ultimately became black. The darker it became, the more fully was the young oyster developed, until at last the spat appeared fully vivified, and exactly similar to that taken from a black-sick oyster—in fact a perfect animal.

The holders of the theory that oysters are of two sexes considered the black-sick oyster to be the male, and the white-sick oyster the female. Now the former are always found thoroughly vivified, the latter never. Then, as impregnation must have taken place in some way, if the diœcious theory is correct, it must be the female which has fecundated the male, a state of things totally opposed to the general rule of nature. We have dwelt at some length on this subject, as it is of the greatest importance that oyster-culturists should understand the mode of reproduction. In artificial breeding there is always a large proportion of spat which is exuded in an immature state, and floats about on the surface of the water at times in greenish mucous masses. This is white-sick spat, which has escaped before its time, owing to the inability of the parent to ntain it. This is apparently an unnatural occurrence ing probably from a change of condition or a change of temperature. This kind of spat forms a considerable portion of the whole; it is possible that a very small portion of it may ultimately become sufficiently mature for attachment, if not carried away or devoured by fish, but the proportion of immature spat that ultimately attains maturity is so small that it may be practically ignored.

The parent oyster goes on producing and hatching its ova for some time, as these may be seen oozing for several days from the same oyster. In fact, from the time the ova are first produced to the time the last germ of black spat is emitted, a period of from three to six weeks probably elapses, the process being accelerated by a continuance of warm weather.

White-Sick.

If an oyster be examined in the earliest stage of its breeding-time, it will be found to contain, principally in its ovaries, a thick milky substance, which, under the microscope, resolves itself into oval clusters of globular atoms floating in a transparent mucous liquid. These clusters are quite free; they have no enclosing membranes, and are in appearance as represented in Figure A, facing p. 275. The mucous liquid in which they float appears to contribute to their nourishment, as it decreases in proportion to their advancement in age.

The second stage is when *cilia* appear at the broader ends of the ovoid groups; motion then begins, and the ova pass from the ovaries into the beard or mantle, within the folds of which it is retained. An oyster in this condition is said to be white-sick.

Black-Sick.

The white-sick oyster is generally supposed to become black-sick in about a fortnight. The lobes of the mantle are permeated in all directions by cobweb-like nerves and glandular ducts, which at this period serve the double purpose of excluding any injurious matter, and supplying the young ova with lime for the secretion of the shell.

The white spat may be said to be putting its clothes on, and when fully attired it emerges from its parental home to seek a separate existence as black spat; they are then very beautiful objects; under the microscope they may be seen to be perfect oysters in miniature—bodies and shells complete; they differ only from their parents in being still furnished with *cilia* or filaments round the mouth of the shells, which give them a slight power of movement and volition, until a resting-place has been reached, when, no longer of any use, they are dispensed with.

Adherence.

It appears that in English waters young oysters must have the water at a temperature of from 65° to 72° to put them in a condition to adhere; the higher the temperature the greater fall of spat you get.

The manner in which the young oyster adheres is not certain, but it is believed to be simply by attraction by cohesion, no traces of any cement having as yet been discovered. Cold is most fatal to their chance of existence, a very few degrees lower than the above temperature causing them to lose their vitality and fall dead to the bottom. ***Oyster spat may be said to swarm like bees, and it has been said to be as uncertain in its choice of locality!***

Age and Frequency of Reproduction.

The age at which reproduction commences has never been exactly ascertained; it is supposed, as a general rule, to be from three to six years or more, though instances are known of oysters being in a "milky" state at a much earlier stage.

Mr. Frederick Wiseman has stated that he has known an oyster white-sick when only a year old, but it is highly improbable that the ova produced from a year- or two-year old oyster would ever come to maturity.

It is believed by some that oysters do not breed every year. Mr. Buckland held the opinion at one time that, like salmon, they breed in a cycle of three, five, or six years. The Irish Commissioners in 1870 formed an opinion that they bred only once in ten years, but this was based upon the examination of a bed during the breeding time, when only ten per cent. of the oysters were found to be white or black-sick. We think that these conclusions were hastily arrived at, for the reason before mentioned, that oysters do not breed exactly at the same time. Mr. Buckland examined a bed in 1875, and, we think, he stated that he found one in six, spatting.

Deep-sea oysters appear to spat earlier in shallow water than at a greater depth. Oysters in eight fathoms of water have been known to spat fourteen days earlier than those in eighteen fathoms of water.

The time of spatting is entirely dependent on local conditions, such as temperature, warm currents, and general climatic influences. Currents which affect one part of a bed may not affect another part only a few hundred feet distant.

In 1878 an oyster was found at Whitstable, white-sick, on the 17th of June, and the same oyster was black-sick ten days later, the temperature of the water being at that time from 58 to 60 degrees (Faht.).

Oysters have been known to spat as late as October, and even November, during a mild season, but in these cases it is exceedingly improbable that any of their progeny survived.

Thus it is seen that oysters breed all through the warm months, though the time at which the spat falls depends as much on the temperature during April and May as through the later months.

The internal development of germs commences in one or other of these two months, and although the 1st of May is the date fixed by custom for the prohibition of the sale of oysters, they may or may not be fit to eat at any time of the year between the 1st of April and the 1st of November.

The number of young produced by each oyster has been variously stated to be between 300,000 and 60,000,000, but the approximation made by Mr. Eyton of 1,800,000, was probably a pretty correct estimate of the total number of young English oysters contained by the parent.

American oysters are said to be more prolific, the fish and its ovaries being larger, whilst its eggs are less than one third as large. Mr. Coleman, of Whitstable, estimated that an American Blue Point could produce 125,000,000 if there was no loss of space, based on the calculation that a single ripe egg measures about one five-hundredth of an inch in diameter.

Breeding.

The difference in temperature between England and France no doubt handicaps our English breeding grounds. In July 1865 the temperature was taken on the same day and at the same hour on the coast of France and on the coast of Essex, when it was found that there was as much as 11° (Faht.) difference between the two places.

The climate of the estuary of the Thames is always more or less unfavourable for a heavy fall of spat, though occasionally, as in 1858, it has happened. As we shall presently explain, a good fattening place is seldom a good breeding place.

In July 1866 the temperature at Hayling Island for six days averaged 78°, the maximum temperature being 81°, the highest point reached during that month in Essex was only 72°.

The conditions requisite for breeding are—

1. Clean collectors.
2. Heat and tranquillity.

Clean Collectors.

If the collectors are not clean, the spat cannot adhere; we have therefore placed this condition first.

It has been known for some time that culch should be clean, but the primary requirement of clean collectors and grounds has not been generally recognised, nor has the fact that the cleaner the collectors the greater the number of oysters they catch.

At an oyster breeding establishment, Dr. Soubenan observed the following, what he called "curious," fact, but he did not point out the moral of his tale. It ran thus:

In consequence of a rupture in the sluice, the water in a basin where oysters had been placed to spat escaped into a neighbouring basin which was in preparation, but in which there was not a single oyster of any kind. All the stones of this basin were subsequently found covered with spat which had been brought in by the water, and the rails of a little submerged iron railway, lying in the pond connected with the works, were so covered with young oysters that they were not used as rails any further on account of the value of the oysters settling on the rails being greater than the value of the rails themselves!

And now for the conclusions we draw from this:—

Firstly, the basin in the course of preparation was quite clean, that is clear from weed or deposits from water, and therefore in a condition best suited for the adherence of spat. Secondly, the rails of the basin in course of preparation were absolutely clean, having been probably almost bright from the traffic along the little tramway. Hence their being so covered with oysters that they were more valuable for collectors than rails!

Another instance of the benefit arising from clean collectors is that related to the writer by an owner of one of the Mersey layings. In the year 1881 he had a much better fall of spat on his grounds than his neighbours, who were equally favourably situated. The preceding winter he had purchased from France some 40,000 oysters that had died during the passage, their clocks and separated shells had been allowed to bleach for some months.

When spatting time arrived, these clocks, &c., were thrown overboard on his grounds on a Friday. The following Monday some were dredged up covered with spat, subsequently the great majority of the young brood he took up were attached to these shells.

Heat and Tranquillity.

The conditions necessary for the development of insect life are also those which are favourable for the production of the young oyster. To the late Mr. Frank Buckland belongs the credit of first drawing attention to the importance of this condition: High and even temperature by day and night, and quiet atmosphere. He summarised these conditions as "Heat and tranquillity," which words have acquired some considerable degree of notoriety, and have from first to last led to a good deal of argument, not tranquil but heated, between oyster-culturists.

The opponents of the tranquil theory say that the water must be well oxygenated, so as to be in the most favourable condition for the reproduction of oysters; they admit the necessity of some heat, but do not want anything above 68 degrees (F.).

The balance of the evidence we have been able to collect is that warm and tranquil summer days and nights, if undisturbed by bad weather and night frosts, will as assuredly result in a heavy fall of spat, as a cold, ungenial summer will occasion an oyster famine. It appears that in the English waters young oysters must have the water at a temperature of from 65° to 72°, to put them in the best condition to adhere. If the spat is in a sticking humour, it will adhere to anything that is free from weed or slime—old oyster-shells, cockle-shells, stones, glass, old tobacco-pipes, iron slag, old shoes—in fact anything that offers a clean hard surface will satisfy the young oysters in warm weather, though their after development greatly depends upon the ease with which they are separated from the substances to which they are primarily attached.

In Buckland's Museum there is a large collection of various materials on which spat has been deposited; amongst them is an ordinary flat iron, concerning which poor Mr. Buckland quaintly remarked that the spat was in such a sticking humour that "if the washerwoman who had used the flat iron had been at the bottom of the sea, the spat would have stuck all over her."

The Food of Oysters.

It has been a debatable question whether the food of oysters was of animal or vegetable origin; the organisms on which molluscs generally feed belong to that shadowy border-line between the animal and vegetable kingdom which we may almost call protozoa.

The little creatures which form the oyster's food are almost all microscopic in size, yet they have spontaneous movement, and are considered by some naturalists to be animals of the Infusoria class.

It is now pretty well known that nearly all molluscs times feed on algæ and conferva, and at other times on diatoms and foraminifera and on all those minute organisms which are held in mechanical suspension in vast quantities in every drop of water. To the practical oyster-culturist it matters little to which branch of the animal or vegetable kingdom they belong, it is sufficient for his purpose to be able to recognise them when he sees them, and to find out whether they naturally exist in the water where he proposes to lay his oysters.

As the season advances it will be necessary for him to find out, by the aid of the microscope, whether the water in which the oysters are placed, either for breeding or fattening, contains food suitable for their requirements, as the chemist by analysis tests the purity of water supplied for human consumption. If examined, the stomach of every oyster will contain myriads of living monads; those very minute things found in dirty water and ponds, the "vibrios," are also to be found, and during the summer months, *i.e.* from April to October, great abundance of a conglomerate organism like a very minute ball, which is called "*volvox.*" The beard of the oyster is also enabled to absorb from the water the phosphates which are derived from the matters collectively forming the phenomenon of phosphorescence at night; these form a most valuable part of its constitution, and give brain and nerve power to the oyster-eater.

Theory of Fattening.

It has long been known that in order to fatten oysters properly, they should be laid down in brackish water, and many estuaries of rivers have long been famous as localities for high-class oysters. Recently the microscope has shown us that it is not the specific gravity of the water that is essential, but the presence of diatomaceæ and infusoria, on which the oyster lives and thrives. On the Whitstable grounds there is, more or less, according to the tides, an eddy over the spot where oysters are laid, and into this eddy are drifted the minute creatures on which the oyster feeds.

A study of the differently situated oyster grounds will show that there are well-marked differences in the character of the oyster, according to the quantity and quality of the plants and animals which form its food.

The soil itself has great influence on oyster life, as it affects the production of the organisms which at the various stages of growth are best adapted to the constitution of oysters.

The green colour of the Essex and Marennes oysters is due to living on a kind of *navicula;* the green chlorophyll is digested and decomposed; the soluble colouring matter passes into the circulation of the animal, and the branchiæ, being the most vesicular portions of its structure, are the most highly coloured. Experiments made by MM. Puysegur and Decaisne proved that if, after oysters had turned green, they were laid in ordinary sea water for a few days, their greenness disappeared altogether.

The Essex oysters, from the Roach and Crouch rivers, are only green when there is an "r" in the month, that is from September to April, during which time the weed, or, crow-silk as it is locally termed, is found to preserve its colour in the river.

We have yet one other function of that wonderful organ the beard, or mantle of the oyster, to describe, and that is the building of the shell.

The beard lines the edge of the internal surface of both shells, and is, as we know, furnished with glands and ducts. These glands deposit carbonate of lime, with a glutinous secretion, as the shell increases at the edges and on the internal surface. The edges of these repeated deposits, slightly projecting one over the other, form the ridges and carinations observable in bivalves.

The beard also absorbs carbonate of lime, and re-deposits it in fine particles, which aggregate and form a delicate horn-like substance, as thin as tissue-paper, and extremely fragile; to this more carbonate of lime is added, making the shell harder and harder. The appearance that a mature oyster-shell presents is that of successive layers or plates overlapping one another; these are termed shoots, and it was formerly considered, even by Mr. Buckland, that each shoot marked a complete year's growth; later investigations have shown that such a guide to the age of an oyster is untrustworthy, as oysters have been known to make two, if not three, shoots in one year, according to their nutrition.*

Generally speaking, it is true that marks on both shells, more or less clearly defined, show where the growth of one year terminates and where that of the next begins; this is perhaps most clearly seen upon the flat shell, where an indented annular groove, more highly coloured than the surrounding parts, and varying from one-eighth to one-fourth of an inch in thickness, frequently marks the yearly growth. Under a variety of circumstances the oyster makes two or even three rings of growth on the round shell. There is a considerable difference in texture of shell between an old and a young oyster, and probably this is a better guide to an oyster's age than any other.

After it has reached the age of five or six years it appears that the oyster does not shoot any more unless its conditions of existence are altered, the shell alone becoming thickened by successive deposits of carbonate of lime.

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* See Figure facing p. 291.

Long experience will enable an expert to guess the age of an oyster from its appearance, up to perhaps six years, but after that an oyster's age is more difficult to tell than that of an "aged" horse.

The lateral growth of shell just described takes place during the warm months; during the winter the shell hardens and thickens.

Before leaving the consideration of the beard, we may add that, as it is the most useful and most hard-working part of the oyster, so we can judge of an oyster's health by its appearance: if the edges are furry and dark lines are seen in it the oyster is in bad health; if kept too long out of water the beard shows signs of distress, the edges first becoming dry and dark coloured, after which the whole body follows its example.

Oyster-shells are useful for several purposes besides Culch. When calcined they form a particularly good description of lime, and are used by farmers as manure.

The more animal matter and the less inorganic matter there is in an oyster-shell, the greater is its value as an article of commerce.

The shells contain—

1. Animal matter.
2. Phosphate of lime.
3. Carbonate of lime.

The proportions were found by Professor Tanner to vary between—

	Organic matter.	Carbonate of lime.	Phosphate of lime.
Whitstable Natives . . to	9·6	85·7	4·7
North Sea	4·1	94·8	1·1

CHAPTER II.

ENEMIES TO OYSTERS.

THE enemies of oysters are numerous and indefatigable. They may be divided into two classes :—

A. Living.
B. Inanimate.

The living enemies may be further divided into :—

A. Those which are directly injurious.
B. Those which are indirectly injurious.

CLASS A.

LIVING ENEMIES.

Subdivision A (*directly injurious*).

1. Skates and Rays.
2. Octopods.
3. Echinodermata (starfish, sea-urchins, &c.).
4. Crustacea (crabs, prawns, &c.).
5. Whelks, &c.

Subdivision B (*indirectly injurious*).

1. Mussels.
2. Cliona.
3. Weed, sabella, acorn-barnacles, annelids, polyps, poch, blubber, &c.

CLASS B.

INANIMATE ENEMIES.

1. Sand.
2. Mud.
3. Fresh water.
4. Frost, ice, and snow.
5. Sewage and other poisonous contamination of the water.

1. *Skates and Rays.*

Among this tribe of fish, the eagle-skate or sting-ray is the most destructive ; and where it is a frequent visitor, as on the French coast, it commits sad depredations on the oyster-beds. The French call it '*le thère*,' and they protect their beds from its ravages by means of palisades of short pointed stakes firmly fixed in the mud under water, and sloping outwards at an angle of 45°. If these protections are not made use of, the rays will swoop down obliquely on the young oysters, and crunch them up in their powerful jaws, fitted, as they are, not with teeth, but with compound crushing-machine palates, in which the shells of a young oyster are ground apart as between two millstones, and the ray can thus easily possess himself of the succulent contents. The male sting-ray is furnished at the tail with two daggers having barbed edges, the female having only one of these formidable weapons.

2. *Octopods.*

Cuttle-fish and other octopods are determined foes of the oyster. Deep-sea fishermen tell us that wherever octopods are dredged up in considerable numbers, a bed of oysters will probably be found not far distant.

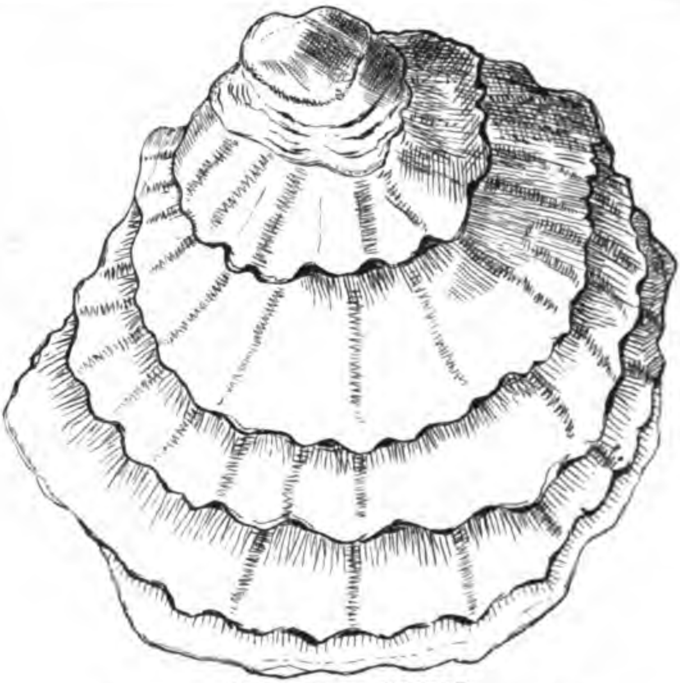
Octopods are found in quantities around the submerged rocks and reefs in the English Channel. The Channel Island fishermen have partly attributed the decadence of the oyster and scallop fisheries of late years around Guernsey to their depredations, though they admit that many other causes have been at work besides octopods to account for the scarcity. The method of attack of these animals is to seize the oyster in their powerful tentacles, and force an entrance through the thinnest part of the shell by means of the horned beak that they can protrude at will.

3. *Echinodermata* (*Starfish, Sea-urchins, &c.*).

Starfish are probably the most pernicious and persistent enemies of oysters. In the estuary of the Thames they are locally known as five-fingers, and they abound on many of the Kentish beds, in fact, in greater or lesser numbers, they may be said to be constantly found attendant on all oyster-beds. At times they are most destructive, clearing up all before them like a fall of locusts, and although they do not attack oysters when the more easily attainable food of mussels can be obtained, woe betide the layings of oysters upon which these pests sweep down, unless beds are properly cared for, protected, and cleaned.

Though known as "five-fingers," starfish are found frequently with only three arms, at other times there are as many as ten, and foreign varieties have from twenty to forty tentacles.

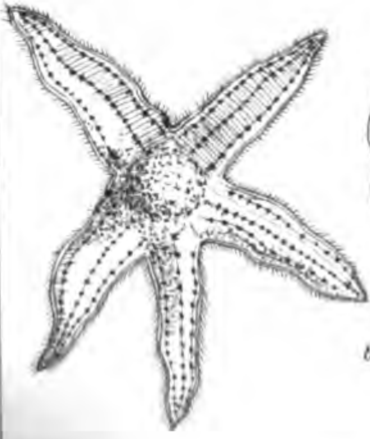
Professor Haekel, in his 'History of Creation,' states that each of the arms of a starfish is in reality a complete worm in itself, similar to any other ringworm or annelid; the stomach runs down the central line of the arm, the posterior end joining with those of the other arms, and forming a central cloaca, the mouths being situated at the anterior ends. A five-finger is thus composed of five worms joined in a cormus or colony; and it follows that a carefully-detached arm of a starfish can lead an independent life; it can then, by the growth of buds radially at its posterior end, again become a complete star. Hence if all the arms but one of a five-finger are detached, and it is thus thought that the animal is killed, not only may that detached arm become five fingers again, but

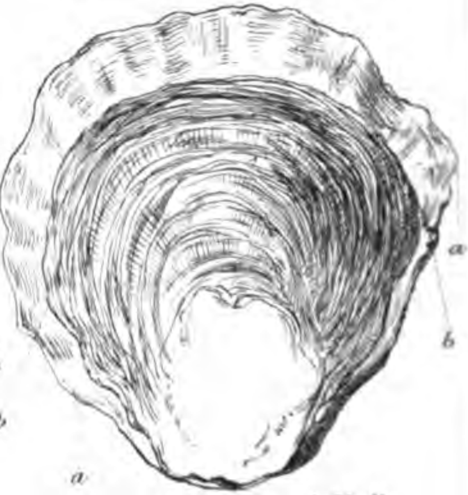


SKETCH OF OYSTER.
Shewing what at one time were supposed to be Annual Rings of growth.

FIVE-FINGERS HANDI-WORK

A FIVE FINGER





a. Outer edge of Round Shell.
b. Outer " " Flat "
The portion of the Flat Shell outside of b has been rasped or whittled away leaving the extreme edge of the Flat Shell only adherent.

the other four may each become five-fingers, so, instead of five fingers we shall have twenty-five!

The arms are covered on the upper sides with a tough skin, so tough indeed that, when a "clock" which had a five-finger as an inhabitant was stamped on, the shells were broken to pieces, and, though one of the five-finger's arms was outside the edges of the shell, it was not separated, and only slightly indented.*

Each arm is provided on its under side with a number of little feet, which it has the power of protruding or contracting at will. This protrusion and contraction acts like a file in removing the surface of a shell on which it is expended; and it is by this means that the starfish attacks its prey. The *modus operandi* is as follows, the result being shown in the figure opposite.

The oyster is seized by the arms of the starfish round the part opposite the hinges; and the filing operation is commenced round the outer edge of the flat shell, two arms being engaged in securing the oyster like a vice, whilst the others are at work filing. Commencing at the outer extremity, the shell is gradually worked away until the points of contact with the round shell are reduced to a thin curved line. When this is accomplished, the greater part of the power of cohesion between the shells is lost, and a very little further filing enables the starfish to introduce an arm and possess itself of its prey. The difference in ease with which an oyster thus filed away can be opened, to one that has not been so operated upon, can easily be understood by any one who has tried to separate two sheets of plate-glass. Laid with the two flat surfaces in contact, it requires great force to separate them; but supposing one sheet to be raised so that it touches the other on one line only, then they do not adhere at all.

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* Clock is the name given to the double oyster-shell after the fish is dead and has become removed.

Starfish are sometimes of use on an oyster-bed, from the preference they show, already mentioned, of attacking mussels, annelids, and even acorn-barnacles, before oysters. So that, when there is much of this kind of vermin on a bed, the five-fingers may be allowed a little " law ; " but their employment in this manner should be carefully and judiciously watched, and certainly not allowed on grounds where the owners have not the means of promptly exterminating them as soon as they have eaten down to the oysters.

Five-fingers are much more plentiful on the south banks of the Thames than on the north side, whilst whelk-tingles are more troublesome on the Essex than on the Kent oyster-beds. When dredging off Whitstable last year, we had frequently thirty or forty five-fingers in a haul; this we were told was a mere " nothing," and our attention was drawn to a fleet of some thirty or forty boats which were dredging on the flats for five-fingers alone. When brought on shore, they are sold for manure; they command, however, but a small price, £1 per ton.

Nine out of every ten clocks brought up by the dredges were occupied by these pests, who were evidently the evictors of the rightful tenants.

Mr. Gann, the manager of the Sea Salter and Ham Company, described to us the following manner of dredging for five-fingers without bringing up any oysters :—

The instrument employed for the purpose is an ordinary dredge, with the thong that is attached to the skin or ring-back loosened, so that there is an interval of about six inches between the bit or knife and the lower network. When dredging, the oysters slip over the bit, and are not brought up ; but the the five-fingers, being of but little greater specific gravity than water, are lifted up, and before they have time to fall are caught in the bag of the dredge.

Five-fingers do not like to be disturbed or to be rubbed on the back, and it has been found that a large dredge, with light iron rings for the back net, will cause them to disappear, at any rate for a short time, from the grounds where it is used.

Sea-urchins.

Sea-urchins—or, as they are called in some places, shepherds' crowns, burrs, &c.—have also been accused of destroying oysters, though it has not yet been clear how they manage to grasp their prey, whilst using their hard powerful beaks for perforating the shell. We think that a burr would have to pound away for a long time without gaining any admittance to an adult oyster's closed doors, but they are possibly capable of destroying the young brood.

Crustacea (*Crabs, Lobsters, Prawns, Shrimps*).

At different stages of an oyster's life all these animals are more or less enemies to it ; the worst are undoubtedly *crabs ;* they will eat oysters whenever and wherever they get a chance.

Fishermen have a superstitious regard for the cunning and cleverness of the wily crab, and marvellous stories are told of its "legal" qualities. The two following examples of such tales will suffice. A friend told us that a crab in his aquarium would take up young oyster brood, which had lately been removed from the layings, turn them over one by one, and examine them narrowly to see whether they had been injured by removal. If uninjured, the crab dropped the oyster with an apparently disgusted air, and seized another. Should this one by chance show marks of abrasion, the crab pounded away with his heavy claw at the weakened spot until the shell gave way, when the other claw was immediately inserted, the fish dragged out and devoured. Was this instinct or reasoning power? may well be asked; the latter, if we are to believe the yarn of another *raconteur*, who gravely informed us that he had seen a crab hovering above a feeding oyster, holding in one claw a small stone, which he poised over the unconscious bivalve. When a favourable opportunity occurred, the crab let go, exactly plumbing the entrance of the gaping shells; the stone fell, "wedging them open," and the crab descended into his oyster *bar!*

Without pronouncing an opinion as to the quality of our friend's pun, or the accuracy of his observation, there is no doubt that crabs will watch oysters like a cat does a mouse-hole, that they will climb over banks, enter drains, and squeeze themselves through traps, to obtain the food they are so fond of.

A writer on the subject referring to the French grounds lately stated that the most deadly of the oyster's enemies there were crabs, called by the French *cancres maudits*, for they may be seen prowling about everywhere seeking for young oysters to crunch and devour. "At times they seem to do it for the pure pleasure of destruction; they have been watched taking the infant oysters in their pincers, and cracking them one after the other as fast as they could. Or, if the oyster is too big and strong to be crushed to death, a crab will lie quietly by until the valves open, when, quick as lightning, in goes his big claw as a wedge, to be followed by the smaller one, with which the oyster is pinched out and eaten piecemeal. Then, when crabs have nothing else to do, they get together in bands to dig holes, carting away the sand or mud on their backs. This buries the oysters, and kills them in great numbers." The same writer adds in another place, that "the black worms silt up the mud, and crabs scratch it over the oysters." It is a fact, that during a short time of neglect a million of oysters were thus smothered in one preserve in Brittany.

In most oyster-culture establishments the young brood are placed on trays in a sort of cage, which is covered with wire gauzework, or close network, to protect them from the crabs. The French call these cages "*ambulances*," and they were instituted in France on account of the depredations of *les cancres maudits.* (See "Artificial Cultivation.")

Lobsters, prawns, and shrimps, as well as crabs, do a vast amount of damage on an oyster laying. Their ravages are committed during the warm months of summer and autumn, when the shell is growing and the spat is floating about in the sea. It is at this time they are most active, and the amount of oysters destroyed before their shell has time to harden is enormous.

Besides crustaceans, many fish feed on the spat of oysters. Mullet, whiting, mackerel, gobies, and all insectivorous fish, will eat it greedily if it comes in their way.

Shrimps and small fish lie under the shell of a breeding oyster, waiting for the spat to be ejected. When this has taken place, they dart out and devour it with great avidity.

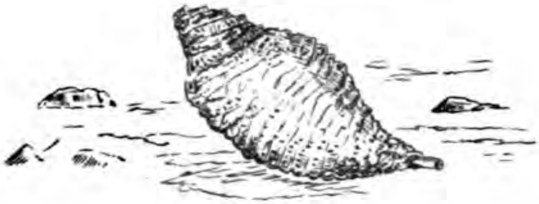
Prawns will attack very young oysters with great success; rushing at the tender shell with their serrated beak, backing well before they make each rush, they soon make a hole sufficiently large to enable them to obtain an entrance and consume the young fish.

Whelks, and Whelk-tingles.

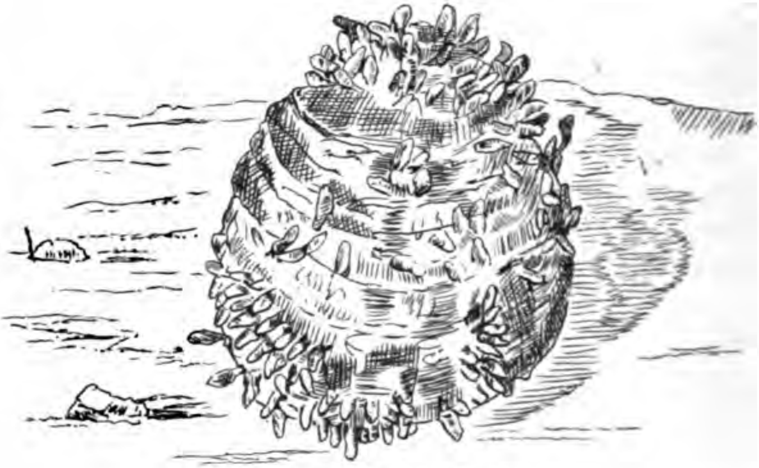
Whelk-tingles are also called dog-whelks or boring whelks (*Purpura lapillus*). They are one of the greatest, if not *the* most destructive, of the oyster's enemies.

This shell-fish has the power of protruding a rasp-like borer out of the cylindrical apex of its shell. Under a powerful magnifying-glass the borer can be seen to be a most formidable weapon, and the way they use it is as follows: Crawling over the oyster until seated with its borer immediately above the heart, the most vital part of the victim, the dog-whelk protrudes its head and body downwards to hold on and balance itself by, and then works away with its borer until a hole, like that made by a drill, is cut into the shell. This hole is cut quite clean, as if bored out with a jeweller's diamond. It is astonishing what amount of devastation these innocent-looking molluscs will do in a very short time; the softer the shell the more rapidly does the dog-whelk do its work. The oyster being thus killed, the adductor muscle relaxes, and the whelk feasts itself at its leisure. If game is plentiful, the whelks, like some other voracious animals, will only eat the most succulent parts of the fish, leaving the beard, &c., to the less fastidious crabs that generally follow in their wake; passing on, on their errand of destruction of the nutritious food that might well belong to their betters.

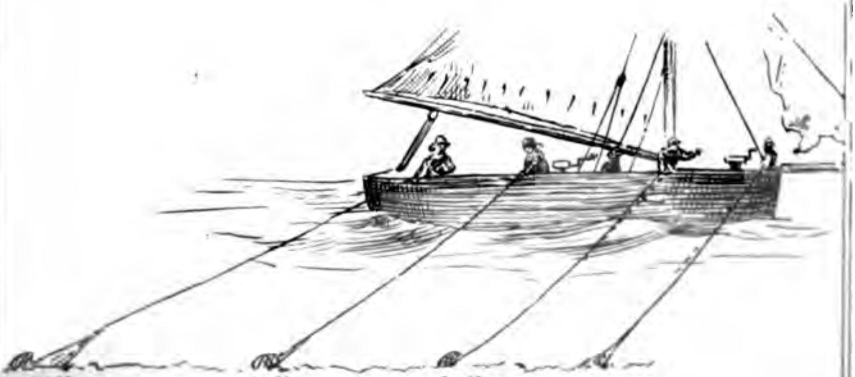
Dog-whelks were at one time such a pest in the Blackwater—the year before last, we think—that fishermen were paid by the owners of beds *6d.* a hundred for bringing them on shore. It is greatly to be regretted that, as these animals are now useless, they are invariably thrown overboard again when dredged up on common grounds. It is thought that the Tyrian dye mentioned frequently in the



DOG WHELK



SPAWN OF DOG WHELK.
on old Oyster Shell.


50 lbs.
55 lbs.
60 lbs.
65 lbs.

Using 4 dredges of different weights.

Bible was extracted from a shell of a somewhat similar kind. Perhaps if the very strong dye that can be extracted from the dog-whelk were made into a fashionable colour like peacock-blue, for æsthetic ornamentation, a market might be found for this extremely objectionable shell-fish.

Dog-whelks breed prolifically in the summer near the shore; they appear to prefer the same kind of deposit as oysters for that purpose—the spawn of dog-whelks may frequently be found on oyster-shells, both living and dead, and also on the boundary-lines made of chalk stones showing the low-water marks of oyster layings. The greatest care should be taken to collect and destroy as much of the spawn of this pest as possible, for each dog-whelk that comes to maturity may kill hundreds of oysters.

"The eggs of dog-whelks (see plate facing this page) have been frequently mistaken for the eggs of fish. They consist of a number of horn-shaped bags, clustered together." (Buckland.) Each bag is not a single egg, but contains several minute seed-like specks; each of these specks will, if hatched, become a tiny dog-whelk. "When the eggs are hatched, the top of the bag becomes loose, and the young ones crawl away" (*idem*).

Common Whelks.

Till quite recently it was not thought that the common or edible whelks were enemies of the oyster, and even now we must admit that for every oyster a common whelk kills, a dog-whelk will slay a hundred.

The common whelks have also a weapon of offence that proceeds from the apex of their shell, which they can use with considerable effect against a young or weakened oyster, and we believe that they will attack and easily kill

At any rate we have no fear that the fisherman will throw the common whelks overboard again on to the oyster grounds, as they can find a ready market for them on shore, being generally allowed to keep them as a perquisite by oyster companies.

Whelks' eggs are often dredged up attached to oysters and culch. In winter they may be frequently met with thrown up on the foreshore. We have observed them all the year round. Mr. Buckland stated that he found the greatest number about the end of February.

They are in a bunch or bundle form, the cells being superimposed one over the other. Each cell will, if crushed, emit a little fluid mixed with minute yellow seeds, which, when placed under the microscope, will be observed to be the young whelks at different stages of development. At first they appear like globules of hard white of egg, afterwards as minute shells, varying from seven to twelve in a pocket. The empty sacs are frequently thrown up on the sea-shore, after the young whelks are hatched.

CLASS A.

Subdivision B. (*Living things which are indirectly inimical to oysters.*)

Mussels.
Cliona.
Weed.
Sabella.
Acorn barnacles.
Annelids.
Poch, polyps, blubber, and all other sedentary organisms which by their decomposition make the ground foul.

Mussels.

Mussels are indirectly enemies of oysters and to all molluscs less delicately constituted than themselves; they will soon overrun and crowd out a bed of oysters. If there has been a fall of mussel spat in any particular locality, every available space is entirely covered by it. As the young mussels grow, they spin a kind of hazy web, by which they retain their holding and hang together. This web is almost silk-like in appearance, and is called by naturalists "byssus." The run of the current brings mud or other deposit, the web of the mussels collects it, and the oysters underneath, unless released by the dredge or harrow, are smothered in their beds.

Mussels grow more rapidly, and can assimilate coarser food than oysters; even were there no deposit of mud they would, if left alone, soon oust the oyster from its place in the struggle for existence. Oyster-grounds suffer most from mussels in shallow water, as they nearly always spat near the shore, though there are instances of deep-sea beds of mussels. The only way in which mussels are useful on oyster-beds is that starfish will always attack the mussel in preference to the less accessible oyster. The flavour seems to the five-finger to be much the same, and, judging from our investigation of oyster-sauce and tinned oysters, we have come to the conclusion that other animals of a far higher order than starfish are content to eat mussels under the more enticing name of "oysters." If not so expensive, they are not unwholesome as an article of food, and so what matters it?

If we were oyster-culturists, especially after a fall of spat, we would prefer to run the chance of more active enemies than to see the young brood covered with mussel "trail," as its spat is technically called.

English mussels are seldom sold for anything but manure, as those from Holland, being much finer and fatter, generally supply the London market.

Cliona

Is a kind of parasitic sponge which lives on the oyster, boring in and establishing itself between the layers of shell. It may be called an oyster's skin disease. Most people who have had anything to do with oysters have observed many live and dead shells pitted with numerous small holes, which run in channels entirely or partially through their substance. Both valves can be attacked, but it is generally the convex one that suffers from the ravages of this parasite. Oyster-shells are frequently quite honeycombed with the effects of cliona, and the *nacre* on the inner surface is greatly discoloured.

Professor Huxley, in his 'Anatomy of Invertebrata,' p. 119, describes the Porifera or Sponges, in which he includes the Clionidæ, as "a type devoid of fibrous skeletons, but possessing silicious spicula of a very peculiar kind, by the help of which they are able to burrow parasitically in the shells of molluscs." Clionidæ existed in the Silurian epoch; but the most plentiful remains of sponges have been yielded by the chalk formations, in which shells of molluscs have been found perforated in a similar manner to the oyster-shell of this day. These perforated shells puzzled geologists for a long time.

When laying down oyster-shells as culch, those that have been attacked by cliona ought to be separated from the sound shells, and burnt or broken up for manure. The reason is that after an attack from cliona the shell turns yellow and black, and becomes quite rotten. If spat adhere to it in this condition it will soon be destroyed, from the instability of the holding and the decomposition of the shell.

Weed, Sabella, Acorn Barnacles, &c.

We have classed all these together, their action as indirect enemies of oysters being very similar, except the crowsilk, &c., on fattening grounds. Weed of any sort on oyster-beds is objectionable, from the fine green slimy weed that grows in the pits, on whose roots the common periwinkle lives, to the cat-tail on cultivated grounds, and the huge *Fucus fusiculosus* that is dredged up from the deep-sea beds.

Some fishermen believe that weed does not do any harm; we have even been told that a weed called "cat-tail" does good, and in support of this a theory has been advanced that seaweeds, like vegetables and plants on land, exhale oxygen and consume carbonic acid gas. If living seaweed thus tends to oxygenate the water, no doubt the theory is sound; but until this be more clearly proved by practice, we are bound to state our opinion that, with the above exception, *all weed is objectionable:* firstly, because it increases the work of dredging, and covers up the oysters; secondly, because at the period of spatting it covers the culch, so that the spat that settle thereon is lost; weed collects mud, which smothers the spat, and generally makes the ground foul.

Sabella is a tube-inhabiting annelid, with an arenaceous covering that accumulates round the cylindrical tube. Sand thus deposited is a coarse, brown, friable substance, commonly called "ross." If it contains the worm, it is called "live ross," if not, "dead ross."

so objectionable because it grows extremely rapidly on and around the oysters, tending to smother them; and when the worm dies, it turns black and poisons the young spat. It can easily be scraped off an oyster-shell, but of course increases the trouble of preparing them for the market. The oyster underneath the sabella will be found quite intact, proving that it is not a direct enemy.

Acorn barnacles, called in the Thames estuary "chitters," are very small barnacles which appear to prefer calcareous substances on which to attach themselves. They are the least harmful of any of the previous enemies we have mentioned, but they form on the culch, and thus prevent the spat from getting fairly attached. Deep-sea oysters, particularly those from the Skelling banks, have frequently larger sized barnacles attached to them, which are apparently of the same nature as acorn barnacles.

Annelids, Poch, Polyps, Blubber, &c.

These are all objectionable on oyster-beds, making the ground foul, and if from any cause they die, decomposition will set in and the very young oysters will succumb to its poisonous influence. The younger the oyster, the more delicate is its constitution, and the easier it succumbs to bad diet.

Poch is a conglomerate of small semi-globular drops, that forms on the outside of oyster-shells; it is of a brick-red colour, and, if squeezed, emits an odour very similar to that of cucumber.

Blubber, called by various other names, such as *squashers, jellies*, &c., is a great nuisance on some grounds. It grows and accumulates very rapidly, and if left alone would soon smother the beds. The Blackwater fishermen collect it from every dredgeful, and then stamp it under foot; the sacs being thus emptied, air takes the place of the liquid, on the pressure being removed ; it is then thrown overboard, and floats away with the tide—if not quite destroyed, at any rate it goes on to some one else's ground. The same objections we have urged against the foregoing organisms apply to polyps, sea anemones, and all other sedentary animals and vegetables; there is little doubt that you cannot have your ground *too* clean for the reception of oyster spat and the general purposes of oyster culture.

The Blackwater and its tributaries, as well as the Colne and the Mersea grounds, are much troubled with blubber. We saw a great deal on Mr. Harvey's ground, though there was not a single five-finger or dog-whelk there, and Mr. Harvey's grounds are no doubt most excellently cultivated.

CLASS B.

INANIMATE ENEMIES.

1. Sand.
2. Mud.
3. Fresh water.
4. Frost, ice, snow.
5. Sewage.

Sand is the most fatal of inanimate bodies to oysters, and therefore will be treated of first. Where there is a sandy coast, or shifting sand-banks are in the neighbourhood, the accumulation of sand proves destructive to oyster-beds, though all other conditions for their successful establishment may be very favourable. This is more or less the case near the Maplin Sands, Southend, the east coast of Jersey, in the estuaries of the Exe, Solway, Flintshire, Dee, and Severn, the mouth of the Aln (Northumberland), Cardigan Bay, and many other places.

After a gale from seaward the sand is silted up over the foreshore and over the shallows, held in suspension by the waves; it is deposited on the unlucky oysters, and either smothers them outright, or when the oyster open its shells, gets between its hinges and into its beard. In the former case the oyster cannot close, and thus falls a victim to its active enemies; in the latter, the sand irritates the fish until ejected from its delicate breathing apparatus; if there is too much sand to be ejected, the oyster is choked.

Mr. Buckland likened the action of the sand in the former case to that of a cedar pencil or a small stone placed inside the hinge of a door, which small object will keep the door wide open.

In 1868, Mr. Dilnot, who was working with Mr. Buckland at the Reculvers Fishery, near Herne Bay (where, by the way, his oyster culture establishment would have been an entire success had not an accident happened to the embankments) wrote: "It occurred to me to try the experiment of covering some oysters, in the experimental trough, with sand and fine gravel; I put just enough over them to cover the shells. I have just examined them, and find those under the sand all choked; others in the same trough, on which I placed no sand, are all alive. I find when the oyster opens to feed, the sand is drawn in between the valves of the shells, and it is unable to throw it out; consequently it dies." Those who think of cultivating or fattening oysters should try first whether the locality is subject to these marine sand-storms; as Mr. Buckland remarks, the question whether it is favourable or unfavourable will be answered by a few oysters as well as by a thousand pounds' worth.

Sand probably causes the oyster to suffer as much as we should if we got a particle of dust in one of our eyes and could not expel it. A knowledge of a peculiarity connected with this taught the Chinese many years ago to wedge pearl mussels open, and to place little images of Buddha inside the shells, under the mantle of the mussel. It was impossible to get rid of the foreign substance, so the mussel—how it must have suffered!—deposited nacre all round the image, thus rendering it smooth and innocuous.

These little pearl Buddhas, though not uncommon, are esteemed as great curiosities, and are still to be found in the houses of wealthy mandarins. The writer saw one at the late Mr. Whampoa's, at Singapore.

The following amusing lines appeared in *Punch* in November, 1880, *à propos* of this subject:—

THE MOAN OF THE NATIVE.

'Tis the voice of the oyster—I hear him complain,
"I *can't* live in this place; here's a sandstorm again!
I had settled at rest 'mid the rocks and the tiles,
They had made me a home, but this sand, how it riles!
It gets into my shell and the delicate fringe
That I use when I breathe; and I can't shut my hinge
When the grit lodges there; so the crabs come at will,
Since my poor mouth is open, they feed and they kill.
I've complained to Frank Buckland, who quite understands,
But he can't undertake to abolish the sands."
Thus the native made moan, and I took up the brown
Bread-and-butter and lemon, and swallowed him down.

Mud.

Shifting mud is a bad thing for spat or young oysters. If spat happens to fall on mud, it is fatal to its chances of existence. After the oyster grows older it does not appear to mind reposing on a muddy bed, as long as the mud is not too soft, and it does not get buried too deep. Oysters laid on soft ground often sink in the mud; but if this takes place gradually, the animal contrives, by the flow of water which it takes in and passes out, to keep an air-hole open

When covered over by a mud storm, however, they have not time to establish communications with the sea, and they get "slubbed" up and die. There are many places in France, such as at Auray for instance, where the oysters are raised three or four times a year from the mud into which they have sunk, and relaid on the surface. There is a bed of oysters in Cancale Bay where the dredge will come up quite full of mud, but it also brings up living and healthy oysters.

A continuous calm is not considered favourable by the French authorities, especially at spatting time; this is almost the only evidence we have collected that interferes with the theory of tranquillity; the reason is that the mud in a slimy state is deposited or settled on the *appareil collecteur*, and prevents the spat taking a firm hold.

At the Ile de Ré in 1868 a comparativly small spat of oysters had fallen at La Moulinade, on the west side of the island, whereas at Chanchardon, on the east side, the fall of spat was quite up to the mark. The cause of this was assigned to the power of the wind to shift the mud; the same wind which brought ill-luck to the west side of the island naturally brought good-luck to the east.

Mr. Buckland, who was at the Ile de Ré at the time, found, upon examining the oyster parks at La Moulinade, that they were in many localities mudded up, but that on the other side of the island the stones on the foreshore were clean. At Rivedoux, this wind had covered the tiles with mud to the extent of sixty or seventy centimetres (about two feet) deep. A calm coming immediately after heavy waves allowed the mud to drop from the dirty water, and to settle on the young spat and smother them. These mud storms, the same authority continues, "are particularly unfavourable to *foreshore* cultivation, inasmuch as the oysters cannot be dredged and cleaned from the sediment which has fallen on them; but it does not apply to our English system, because we can gradually clean the mud away with a dredge." Again, it should be observed that all places are not liable to mud storms; but a bank of loose mud should always be regarded as a dangerous neighbour by the owner of an oyster-park or laying.

The flats at Whitstable consist of shelly ground, clay and muddy sand; the fishermen say that the oyster prefers the muddy sand during winter, where it can lie close, and get protected from gales and their effects on the rolling gravel.

There appears to be no doubt that in winter the brood are more difficult to dredge up, and the ground becomes very much harder in cold weather, particularly on such parts of the Whitstable Flats where there is only from six to eight feet of water at low tide. It has been stated that oysters bury themselves and hibernate in the winter; the foregoing may partly account for the tradition.

Fresh Water and Rain.

Fresh water does no harm in moderation; when mixed with sea-water quite the reverse, as oysters, when young, appear to fatten and grow more quickly where they are subject to the effects of numerous fresh-water deposits, but with too much fresh water the fish of the oyster increases in size, and becomes fat and flabby eventually; the oyster gapes and dies, or, as an old fisherman said, they "busts theirselves open."

Salt-water fish, with the exception of the salmon and a few others adapted for the change, transferred to fres' water quickly die. It is therefore dangerous to make oyster-pits or beds where they are liable to being submerged in fresh-water floods, or what are called "freshets." Oysters will live much longer out of the water, if placed on their deep shells and covered with seaweed, than when, as is usually the case in London, they are placed in tubs of fresh water; salt and oatmeal only makes the water less suitable for them.

There is a saying among oyster-culturists that a fall of rain is a good thing to settle the spat, and in those years that spat fell plentifully there was occasional rainy weather, besides "heat and tranquillity."

Care should be taken that any land drainage should be led clear of the pits and ponds where oysters are laid for protection, or preparatory to being taken to the market.

Ice, Frost, &c.

Ice coming down rivers is frequently left aground by the ebb tide, and takes up a berth on the foreshore. As the volume of ice under the water is much greater than that above, it often grounds below low-water mark, and if any unfortunate oysters happen to be beneath the small floe, it will freeze them on to itself, and with the incoming tide, "walk off" with the oysters attached. When the ice melts, it drops the oysters again, perhaps into water much deeper than they have been accustomed to. In their weakened state they will then succumb, and thus in severe frosts many beds are robbed and their contents killed.

Ice also prevents dredging. During a severe and continuous frost the boats cannot work, and the five-fingers and other enemies have the field to themselves. Some thirty years ago, when a severe frost set in, the river Roach could not be worked, as the ice was over an inch thick on the surface. Thousands of five-fingers then made their appearance, and killed a great quantity of brood.

The effects of the cold in February 1879 were most disastrous. The loss on the Swale estuary alone was estimated at £20,000. French and Irish (seconds) that were laid down all died. Though up to February 8th Natives were not touched, merchants reduced their price 75 per cent. to induce purchasers! The young brood appeared hardier than the parent oysters. This same winter was very severely felt in the Blackwater and its tributaries and estuary, where the cold killed all the French oysters and a great many Natives that were left in exposed places, though the Natives laid in pits escaped.

At Wyvenhoe, Messrs. Harvey attribute the fatal effects of cold on the beds to the increased density of the water; but as the greatest density of this brackish water near Mersea is at about 39° Fahr, it is difficult to see why this should be the cause. Frost sometimes freezes the shells together, and the oyster dies from starvation. Oysters have been opened and found to contain the fish enveloped in a lump of ice. In this state, though dead, it is perfectly good to eat, if eaten at once, though when it is thawed the dead animal becomes quickly putrid. In winter, after a thaw, snow-water comes down the rivers and increases the volume of fresh water, and thereby sometimes causes great harm to oysters.

Sewage, the Pollution of Rivers, &c.

It will not require many words to convince any one who thinks on the subject of the direful effects of sewage on oysters, for, even if they are not killed outright by the withdrawal of oxygen from the water, and the substitution of other noxious gases, it will assuredly render the oysters totally unfit for human food. The rare cases where oysters have acted poisonously are to be attributed to this cause.

Although oysters have very delicate constitutions, we may fairly assume that, if the transition to impure feeding is very gradually reached, they will, like the human being, become accustomed to larger and larger doses of the poison, and will eventually become acclimatised, as it were, to obnoxious aliment.

These cases are however exceptional, the usual results of an outlet of sewage being the complete destruction to the oyster-beds it contaminates.

The question of the pollution of rivers is very important to oyster culturists; and these pollutions are such a hindrance to the proper development of other fisheries, that it would be as well to give some of the facts ascertained of late years, as to the effects of sewage and other pollutions.

LIVERPOOL.—The Mersey has suffered very considerably in this way; one of the witnesses examined by the Inspectors of Sea Fisheries stated that he recollected when the banks on both sides of the river were clean sand, and the Bay at Waterloo a light-coloured clean sand. He also remembered when a wreck at Rock Lighthouse was covered with small mussels. "There are no mussels there now! The bank of the river consists of dirty sludge. The sewage and chemicals from Liverpool are materially injuring the fisheries, and the smell is obnoxious fourteen miles out." A complaint was also made that the steam dredges are continually depositing a large mass of hard stuff eight miles north-west of the Bar lightship, and are destroying a valuable trawling-ground.

GUERNSEY.—The practice of depositing ballast round the coasts of Guernsey has destroyed a valuable trawling-ground, and rendered the adjacent waters unfit for oysters. This practice has, however, been discontinued (1882).

TYNE.—The hoppers bring down large quantities of dirt from the bed of the river, and refuse from the alkali and other manufactories. The Tyne Commissioners alone dredged up 500,000 tons of rubbish in one year; "this deposit has filled up the crevices in the rocks, and crabs and lobsters have almost entirely disappeared."

TEIGNMOUTH.—A good deal of granite sand comes down from Dartmoor. From Newton comes the drainage and refuse of the gas-works and a tanyard, making the water there sometimes as red as blood. About two years ago Mr. Baxter laid two cargoes of Irish oysters in the river on a Thursday. On Friday there was heavy rain, and on Saturday they were all nearly dead. The flood brought down a lot of sediment which choked or buried the oysters.

PLYMOUTH.—A vast amount of mineral sand and clay comes down by the rivers from the counties of Devon and Cornwall. These deposits, coming into contact with the chloride of sodium in the salt water, fall on the shell-fish banks and spawning-grounds, form an oxide, and destroy the fish! In these cases the whole oyster turns green from copper, reddish-brown from iron, &c.; and whenever an oyster-lover meets such, let him not try experiments *in corpore vile.* If the beard alone is green, as with the Marennes and Roach river oysters, let him eat without fear, for these are vegetable, not mineral results, and such oysters in our opinion are the very best.

If the oysters that have suffered from mineral deposits are relaid down on clean grounds, they will gradually resume their natural colour, and become again quite good to eat.

Evidence has also come from Morecambe Bay, from Leigh, and from many other places, not excepting the mouth of the Thames, to show that where manufactories or sewage works empty their refuse, *fish of all sorts* have been driven further and further out to sea; and many testify to the fact that scarcely any fish will keep alive westward of Gravesend until clear of London.

CHAPTER III.

CONSERVATION OF DEEP-SEA BEDS.

A.—*Natural Causes.*

WE have treated of some of the conditions which affect the growth, condition, and production of oysters, under the head of Natural History, but there are certain active causes influencing the formation of deep-sea beds which we will now refer to.

Temperature acts in the greatest degree at the time of spatting; its after-influence gradually lessens as the oyster grows and becomes more robust. In an early, warm summer, deep-sea oysters have been known to get "white-sick" about the end of May, and "black-sick" a fortnight or so later. If the season is late, they may not become white-sick until August or September.

The action of the Gulf Stream is an important factor in considering the temperature of the Channel and the Bay of Biscay. It has been likened to that of a pendant floating in the air. If the stream sets towards England steadily, the water in the Channel and the North Sea still remains warm, as a pendant is kept in one direction by a strong steady breeze; but if other causes supervene to direct the current elsewhere, the effects it produces are either evanescent, or not sufficiently strong to counteract the influence of the Arctic currents which occasionally sweep down the west side of the British islands and the North Sea.

The heat of the sea-bottom, and of the water in contact with it, at moderate depths, is affected by the rays of the sun, and though the water thus heated must quickly rise, the submerged surface is affected by this cause, and will continue to give forth heat some time after the rays of the sun have been withdrawn.

It has been said that alterations of temperature have not any great effect on the inhabitants of the bottom of the sea, owing to the supposition that no great amount of cold can possibly be experienced there, sea-water being at its greatest density at about 40° Fahrenheit.

Here, however, theory and practice do not agree. Mr. Polley, a dredgerman of forty-two years' experience, when examined before the 1876 Commission, said that "he knew a nice bed of scallops which existed a year or two previously, to the westward of the Straits of Dover, and which showed at once, when the fishermen drifted on to them, that they were to the westward of the oyster grounds. One spring, after a severe winter, he was dredging on this bed, and he found that all the scallops had been killed by the cold. The same spring he found all the spider-crabs near Jersey to have been destroyed from the same cause, so that, whereas in former years they had no difficulty in getting a large basketful in a day, that year they could not find one."

This shows how the bottom of the sea can be affected by temperature; other dredgermen and deep-sea fishermen express similar opinions confirming this view.

They say also that cold breaks up the ground below the water, and renders everything there brittle in the same way, though perhaps to a less degree, than it does above water.

Depth and Density.

In the inter-tidal zone, when high water occurs about noon during the spatting season, the action of the sun is greatest, and development of life most active about high-water mark. (Professor Sullivan.)

It is the reverse of this in the zone below low-water mark. When low-water spring-tides occur in the middle of the day, as is the case on the coast of France between Cape La Hogue and Cape Frehel, and around the Channel Islands, the spat of those oysters that are laid in the shallow water outside of low-water mark have the best chance of existence, as the warmer the water, up to certain limits, the greater the activity of the very young oysters in moving, feeding, and growing. The rise and fall of the tide is also of importance; in the above-named localities there is a rise and fall of over forty feet. The alternation of comparatively deep and very shallow water exposes the oysters to successive alternations of temperature and to the effects of the variation in the amount of gases in the water, which are by no means favourable to successful reproduction.

Although oyster culturists differ on the subject, we think it has been proved by actual experiment that the spat when first emitted in the black-sick stage is of less specific gravity than the water surrounding the parent oyster, and that it rises towards the surface for a time.* How long this condition lasts has not yet been satisfactorily determined; it may be only a few hours, but it is possible that several days elapse before it descends in a sticking humour. If it has been drifted into very deep water, the pressure will have a retarding influence on the development of the germs as they descend, and at a certain depth, which as yet is unknown, the spat is destroyed.

Again, as it appears probable that both young oysters and spat have a better chance of living under conditions of pressure which are natural to them than under new conditions, a knowledge of the elevations and depressions of the sea-bottom are of importance, as affecting the distribution of oysters, and the directions in which the banks extend.

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* One oyster culturist says that "last year he never saw so much spat floating, yet not one did he breed." Another says: "Yes, that's true; but the year before last they had just as much floating, yet they had a capital fall of spat."

Besides affecting pressure, depth influences the amount of light, aëration of the water, and its temperature.

Oysters dredged up from greater depths than twenty-five fathoms are generally thin and coarse; thin, because the amount of alluvial deposit containing certain kinds of infusoria necessary for their food is mixed with so much sea-water that their food is weak and scarce; and coarse, because they have to feed on foraminifera, which has much the same effect on oysters as a meat diet has on pigs!

The large shallows in the estuary of the Thames, where the banks are just covered at low-water neap-tides, the Kentish flats, &c., become unduly heated during the long summer days, and there appears to be no reason to doubt that this is the cause of the Burnham, Roach, and other rivers thereabout, being very favourably situated for the production and deposit of spat, the tide as it rises bringing in the heated water and raising the temperature of these rivers.

Tides and Currents

Exercise great effect on oyster culture by running away with the spat until it dies, or is deposited in localities unfavourable to its continued existence. Mr. Buckland said that the young oyster in its first stage of life moved easily about in the water—"as thistle-down in a field is carried to and fro by light airs." He also thought that the cilia enabled the spat to guide themselves to a certain extent, but of course they could not make headway against the course of the current, and he likened them to Horace's boatman:—

> "Si branchia forte remisit,
> Atque in præcipitem prono rapit alveus amni."

Currents also form eddies, both in rivers and in the open sea: where there is a bend in a river, an eddy generally forms on the inside of the curve, and here the spat can float up and down, and, being thus detained, has a better chance of resting.

Upon a large scale this eddy theory is very important; one of the reasons why oysters breed, or rather used to breed, so abundantly in the deep bays on the west coast of Ireland—Kilkerran and Birturbuy bays, county Galway, to take two examples, is that innumerable eddies and currents are formed by the many islands in these bays.

In Cancale Bay, and on the west side of the Ile de Ré, there are natural beds of oysters outside in the sea, and the spat is brought inshore by the currents and deposited either on the *parcs*, which are made on the foreshore, as low as possible, or in very shallow water, from whence it is dredged up by hand.

Nature of the Sea-bottom.

The nature of the sea-bottom involves another question than that already treated of under the head of enemies, in relation to deep-sea beds; it is that if oysters fall on rocky or uneven bottom, and survive, they are practically lost, as it is impossible to dredge them up from these grounds, the bottom being called too "fasty" to be worked, i.e. that the dredges catch fast at the bottom, and are either capsized or lost.

If the sea-bottom round the Channel Islands were but as smooth as the North Sea, and the North Sea had as strong scouring tides, and water as well suited for the food of oysters as that of the Bay of St. Malo, deep-sea oysters would be better and more plentiful.

B.—*Artificial Causes.*

Dredging.

Different descriptions of dredges are used, according to the depth of water and character of the bottom. Dredges are made on nearly the same plan on all parts of the coast; the only difference being in their breadth and consequent weight, and in the character of the body of the dredge.

Deep-sea dredges for rough bottoms have the under part of the bag made of iron rings, from two to three inches in diameter; the upper part is made of strong netting, as it is not exposed to the wear and tear of being dragged over the ground.

Deep-sea dredges for muddy bottoms have the bag made of stout canvas, with numerous small eyelet-holes in it.

Where it is desired to bring up brood uninjured, a hide net is substituted for the iron rings; in the Blackwater they use " half skin-backed " dredges, the other half of the lower side being made of wire network.

The largest deep-sea dredges are used in St. George's Channel; they are frequently 12 to 15 feet broad. They are towed astern of the boats, and are left overboard for a much longer time, as they have a large carrying capacity.

Dredges that are worked on the side of boats vary between 16 and 17 lbs. as used on the Whitstable grounds, to the 70 lbs. deep-sea dredges. Whatever their weight, their framework is constructed in the same manner; the lower part of the frame is flattened and turned forwards at such an angle as to enable it to scrape the surface; this scraper is called the "bit" or "knife," and to its ends are welded two iron rods; these, after curving to form the narrow sides of the mouth, are united together and form two sides of a triangle, which is bisected by a strengthening piece, the base of the triangle being made by a piece of iron called the "warbin"; this is welded into each side, its apex fitted with a shoulder for convenience of working on the gunwale, and with a ring to which the dredge-rope is made fast.

The free ends of the bag are fastened to three pieces of wood, the "side-sticks" and "catch-stick"; the side-sticks help to distend the bag, and the catch-stick gives a convenient hold when the bag is turned out.

A great deal of skill is necessary in using the dredge, and the greatest attention must be made to the force and direction of the wind and tide; but of that more hereafter.

The size of the iron rings forming the under side of the bag are regulated by the size of the ring which in certain localities is used for measuring the oysters; those that pass through the ring being unmarketable.

The meshes of the netting forming the other side are of about two inches square.

Where the grounds are occasionally rocky, or where large stones are sometimes found, the dredge-rope is first shackled into the left lower edge of the framework; it is then brought along the middle bar, and a clove-hitch taken round it with a strong thin piece of hide about six inches below the ring; the rope is then stopped to the ring with a piece of spun yarn, leaving a few inches of slack between the hide and the ring. The dredge, thus fitted, hangs square until it meets an impediment, on it "setting" fast, the spun yarn bre the rope slips through the hide, and the dredge is recovered capsized, a few oysters or culch only remaining in the lower end.

French fishermen do not appear to use this contrivance, and they therefore dread working where English dredgermen can work with impunity.

Large dredging cutters can work six dredges at a time, three forward and three aft, on the side of the boat, the weights gradually diminishing from forward aft—that is, the dredge worked nearest the stern should be the lightest, say 45 lbs., the next 50 lbs., the next 55 lbs., next 60 lbs., the next 65 lbs., and the one nearest the bow 70 lbs. The reason of this is obviously that they should all dredge in diverging lines, the foremost dredge, having the least rope, is the most perpendicular, and therefore requires to be the heaviest. (See plate facing p. 297.)

This plan prevents the dredges from dragging together. If the dredges "jump," they require more rope; the men occasionally feel the rope; if "working" well, they can feel the dredge scraping smoothly along, the only irregularities being caused by those of the bottom itself.

The direction of the wind makes a very great difference to the "catch" of the boats.

Where the oysters lay in streams in the direction of the tidal currents, as is generally the case on deep-sea beds and banks, the wind is most favourable when it is at right angles to the stream of oysters; the boats then lay to, and drift with the tide. If the wind is blowing parallel to the stream of oysters, the boats can only dredge across them, and the difference in the result is very great. A boat will get 1000 oysters in an hour in one case, and will be lucky to get 200 an hour in the other.

Steam dredgers.—We have not entered into the question of steam dredgers. We do not think they will pay their way in competition with the cheaper sail-power. It is very difficult to regulate the speed of the engines, and the dredges do not *bear* so well when worked from a steamer. Still they have two great advantages, one of being able to work in any direction, irrespective of the direction of the wind, and the other in not being delayed by calms and contrary winds in proceeding to and coming from the fisheries. Steam dredgers with sail-power would probably be the most advantageous, but we have not yet seen this class of vessel employed.

Hand dredges are allowed by the French Government to be used at some places on the coast. The fishermen and fisherwomen are allowed to use these dredges as far out as they can walk, and they tow them along by a band round the shoulders or waist; the young oysters thus caught are laid down on the fattening beds; and cleaning, sorting, &c., gives employment to many hundred people. There are no pits, so called, though the ground being composed principally of mud, the oysters are kept wet, even at extreme low water.

M. le Commissaire de Marine at Cancale told us that they had lately to imprison and fine one of the fishermen. The man was very tall and powerful, and at low spring tides he would go seaward until his chin was level with the water, and would then seize the dredge-rope between his teeth, and thus almost do the work of a dredging boat. As the oysters are most plentiful on the edge of the bank, in about six feet of water, the man by using this means obtained a far greater quantity of young brood than the other fishing people. At first there appeared to be no law to prevent this, but the difficulty was overcome by prosecuting him for using a dredge which was not a *hand* dredge.

Before we conclude this portion of our chapter, there are two points which deserve consideration, i.e. the difficulties attending dredging at night and during moderately rough weather; these have been exaggerated, whilst the difficulty of dredging during the prevalence of winds from unfavourable quarters has not received its proper share of recognition.

When the Oyster Bill of 1876 was brought forward, there was an outcry among dredgermen that, if the Bill passed, they would only have April and September and October in which they could catch and sell deep-sea oysters, as, from the beginning of November to the end of March the weather would practically prevent dredging on the North Sea and Channel beds. It is true that occasionally a spell of very bad weather will prevent our well-found boats from going out in the winter, as well as in the spring or autumn; but, if their catch will pay for the wear and tear, it would have to be very bad weather indeed that would keep such a boat, for instance, as a Jersey dredging cutter in port. October 1882 was an exceptionally bad month, and the Channel boats could scarcely go out at all, but in November there was but one gale of wind, and in January of this year (1883), one Channel oyster boat alone obtained over 50,000 oysters!

These remarks do not apply to open dredging-boats or to ill-found or ill-favoured smacks, but to the real Channel dredging boats, that will keep the high seas in any weather. The kind of craft that have in years past left Jersey, on a dark winter's eve, with a falling barometer, and a south-west gale blowing, sailing down to Granville on the coast of France, and working all night on a dead lee shore—they have returned to Jersey next morning, laden with the spoil poached from the French grounds; on these occasions they have dredged for oysters when the sea was running so high that they could only work one dredge at each extreme end of the boat, as they were rising and falling so much that each dredge only worked alternately with the other. Even then they used to bring back sufficient to pay them better than a month's more honest work on their own grounds. But those beds off Granville exist no longer, and a French Government steamer lays there now to protect the Reserve beds off Point de Champeaux and the Granville and Cancale beds farther off. We mentioned the subject to endeavour to prove that *where oysters are plentiful, fishermen will soon find boats and means to work for them.*

As to "Dredging during the prevalence of winds from unfavourable quarters;" we respectfully venture to submit these remarks to those who think, with the Royal Commission of 1866, that "but little skill is required in working the dredge" (page 7, Appendix of their Report), and to inspectors who examine grounds, and see not what there is to be seen, but what the fishermen please to show them!

To render our meaning clearer, let us put a supposititious case: Supposing we are the managing men of a company whose ground is going to be inspected by a gentleman who, however clever as a scientist and unbiassed as a judge, has no practical knowledge as a dredger or a seaman. If we wish to show our ground at the best, we take him to those parts of it where we can work the dredges along the "stream" of the oysters; if we, however, wish to show but few oysters, we would take him to a part of our grounds where the wind would compel us to work across the "stream;" or perhaps, if less honest still, we would by a very little manipulation of the dredge, that would be unobservable to any but a practised dredgerman, arrange the towing-rope so that the dredge should apparently "work" well, but if oysters were in heaps down below, not one would it bring up!

Harrowing and Trawling.

Most owners of oyster grounds use harrows for removing the weed and slub, thus cleansing the beds and giving young oysters more room to grow in. Harrows are about four feet square, they have on their under sides a number of small wooden pegs four to six inches in length; these pegs should be so placed that, when the harrow is used, each peg should work over a different line to the others. The size of the harrow and the weight on its back is regulated by the nature of the ground, the hardness of shells of the oysters, and the quantity of accumulated mud, weeds, &c. The French authorities use the harrow on the Government Reserve beds, and have lately paid the *gardes jurés* to work the harrow on the Cancale beds, where there has been a deposit of mud.

Harrowing is particularly useful on deep-sea beds during the early summer months, as it will help to prepare the beds for the reception of spat, by disturbing the silt, &c., which is then carried away by the tide.

We have coupled harrowing and trawling together, as they appear to have much the same effect on deep-sea beds. Both tend to keep down weeds and to disperse oysters. Trawlers say that they endeavour to avoid oysters, as they tear their nets, though the English trawlers often bring into port large quantities of oysters, brought up, we are und to suppose, unintentionally! French trawlers are arefully looked after under the minute inspection of their authorities, that it would be impossible for them to bring any oysters on shore, and therefore trawling is permitted all the year round on the French coast, as it is on the English, except where protective rights are enforced.

Trawlermen think, and rightly so in our opinion, that every grant or concession of oyster grounds made by the Board of Trade is a direct invasion of their rights; for as soon as the grant is confirmed, it becomes illegal in the appropriated fishery to use any other instrument than hooks and lines and nets for catching floating fish. Inshore trawling for soles at night, for example, on these grounds—one of the most profitable sources of their living—is prohibited.

In the Bay of St. Malo the line of Government Reserve beds divides the Granville from the Cancale fisheries. In one part of this ground oysters have become again very productive, whilst on other parts there are hardly any. As trawling is strictly prohibited on the beds, those that contend that it is beneficial to oysters point to one part, whilst their opponents instance the other! Practically the question seems to us to be simple enough. Trawling for flat fish on oyster grounds with vessels having *beam* trawls will do more good than harm, provided that the majority of the oysters that are dredged up are thrown overboard again, and returned to their beds. It is true that the iron ends of the trawl beam will crush and destroy the young brood or spat that it happens to drag over; but weed, mud, and other enemies are disturbed by the trawl, and the ground rendered more fit for the reception of spat.

But chain trawls are a different thing. Instead of a hemp rope, the trawl is then fitted with an iron chain at the bottom of the net; this chain adapts itself to the inequalities of the bottom, and is most destructive to oyster beds; during the autumn, when the shells are most tender, the heavy iron chain will break off the young shoots and do great harm.

Trawlers have lately found oyster beds in the North Sea. The huge "Skelling Bank" off Heligoland consists of numerous patches of oysters; other great oyster beds have been found off the Dutch coast by trawlers.

A trawl has a beam which spreads about 40 feet, and, especially in very deep water, where dredges will not work nicely, it picks up a great many oysters. If trawling is made into dredging on a large scale, it should be subject to the same laws.

Rings for Measurement.

The object of ring measurement is to prevent fishermen removing immature oysters from the deep-sea and other beds. Where "ring" laws prevail—and they are widely enforced in France—all oysters that pass through a ring from two and a-half to three inches in diameter are supposed to be unsaleable and unmarketable, and should be immediately returned to the sea.

We have, however, no hesitation in saying that these ring laws are frequently honoured more in the breach than the observance, and that the expense and trouble of enforcing them are greater than any benefit that arises where they are always infringed. Fishermen will always give themselves the benefit of the doubt, and when the oyster is declared to be unsaleable, in many cases, such as on deep-sea beds, it is too late to put it back again; the boats may be away four or five days, or even longer, from port, Sunday intervenes, and the immature oysters are half-killed before the possibility of re-laying them occurs. Practically they are eaten by the fishermen or their friends, or thrown away.

In framing rules and regulations on fishery matters, it is most desirable that the interests of the public and the interests of the fishermen should run together; with this object in view, it was suggested to the States of Jersey by Commander Anson, late of H.M.S. *Dasher*, that it would be advisable to allow the dredgers five per cent. on the value of all oysters brought on shore, provided that they would agree to return to the beds all immature oysters, whether they were able to pass through the ring-gauge or not.

The percentage, Captain Anson stated, was arrived at from calculating the proportions of young and old oysters, by taking the average catch of the Jersey boats in one month, and reducing the immature oysters to one-fourth their number, old oysters fetching four times the price of young ones.

The States of Jersey appointed a Committee to consider the matter, and we believe it is still "left sitting." The wheels of the Jersey legislature are, however, old, and it requires a long time to overcome their inertia!

A ring for measurement is entirely a fallacious test as to the age and condition of an oyster. A native "Tom Thumb," or dwarfed oyster, will pass through a ring 2 inches or even less in diameter, though it may be five or six years old —and such as are sold by retail for 3*s.* 6*d.* a dozen—whilst young "thrifty" North Sea or Channel oysters, containing not half the quantity of the fish in Tom Thumbs, will frequently not go through a ring of 3¼ or 3½ inches in diameter, and are dear at 1*s.* a dozen.

We have seen deep-sea oysters which have been considered only sixteen months old unable to pass through a 2½-inch ring. Inside they were thin and watery, whilst the shell was so fragile that the outer shoots could be easily broken by slight pressure between the finger and thumb and in some cases the shells were so friable that it was impossible to open the oyster in the usual manner.

Removal of Culch from Public Grounds.

The removal of culch from oyster beds is extremely prejudicial, and in many parts of England complaints are loudly made that private owners remove culch from the public grounds on to their own layings. If these complaints are well founded, such a detrimental practice should be made illegal, and punishable by heavy fine.

It would be far wiser if, instead of putting the old shells into the dust-bin, or burning them for lime, they were collected and returned to the beds; but whilst people can get them on public grounds for nothing, they will not pay for the trouble of collection even by the dust contractors. In this respect the French, in some places, are even behind us, for we have seen their dredging boats at Cancale and Granville unload shingle, culch, brood, half-ware and ware, all mixed together, and the lots sold on the beach by auction just as they stand; the practised eye of the buyer detecting whether there is more culch, &c., than oysters, or *vice versâ*. The young brood may be laid down to grow and fatten or die, as the case may be, but actual harm is done to an oyster-bed by every old shell that is removed. On deep-sea beds there are often large detached stones; a mistake that dredgermen always make is that when, after a good deal of difficulty, one of these "small Gibraltars" is hove up, overboard again it goes!—on to the same ground, to be probably the cause of similar hard work, and perhaps unmellifluous language, again and again, if not to the same men, to some of their dredging companions.

It would be very easy to put these incumbrances on one [illegible] d to deposit them elsewhere, and thus really work [illegible] leanly.

CHAPTER IV.

ARTIFICAL CULTIVATION—FORESHORE BEDS AND PARKS.

THE oyster culturist should in a great measure be guided in his choice of locality by the presence or absence of natural beds of oysters in the neighbourhood.

In many instances, both in England and France, thousands of pounds would have been saved if the promoters of the various enterprises had recognised the fact that, where oysters are not naturally present, it is probable some important conditions necessary to their development must be wanting in the soil, temperatures, or water of the place.

The best places for the industry are estuaries of rivers, the arms of harbours and protected bays, and ebb-dry shoals and foreshores. Where there are disused salterns or salt-pits, oyster-ponds are almost ready made. In the first successful attempt to breed oysters artificially in England a saltern was used, in which salt had been made the previous summer, but which had been cleaned out and shingled.

A little practice in oyster culture is better than much theory, so a few oysters should be laid down and carefully watched. If they gain in flesh or "fish," as it is called, the place is suitable for fattening; and so on as to experiments in spatting, wintering, &c.

Some flat ground near the shore having been selected, the next condition is that it should be capable of holding water naturally or artificially. If already water-tight, as it were, so much the better, but if not, a coating of clay or blue mud must be laid down sufficiently thickly to prevent the water from escaping, a few inches of sand must then be placed on the clay or mud, and a layer of shingle, cockle-shells or old oyster-shells for a "top dressing."

The ground having been thus prepared, means of ingress and egress for water must be provided by the erection of banks and sluices. A model oyster farm (see plate facing this page) would comprise about twelve or sixteen acres, half devoted to breeding, and half to pits or ponds for wintering and for the young brood and last year's spat.

The shape of the wintering ponds should be *oval,* so that the water may more easily run off than it would if they were rectangular; the number of ponds should be as few as possible, in order to reduce the expenses of constructing sluices.

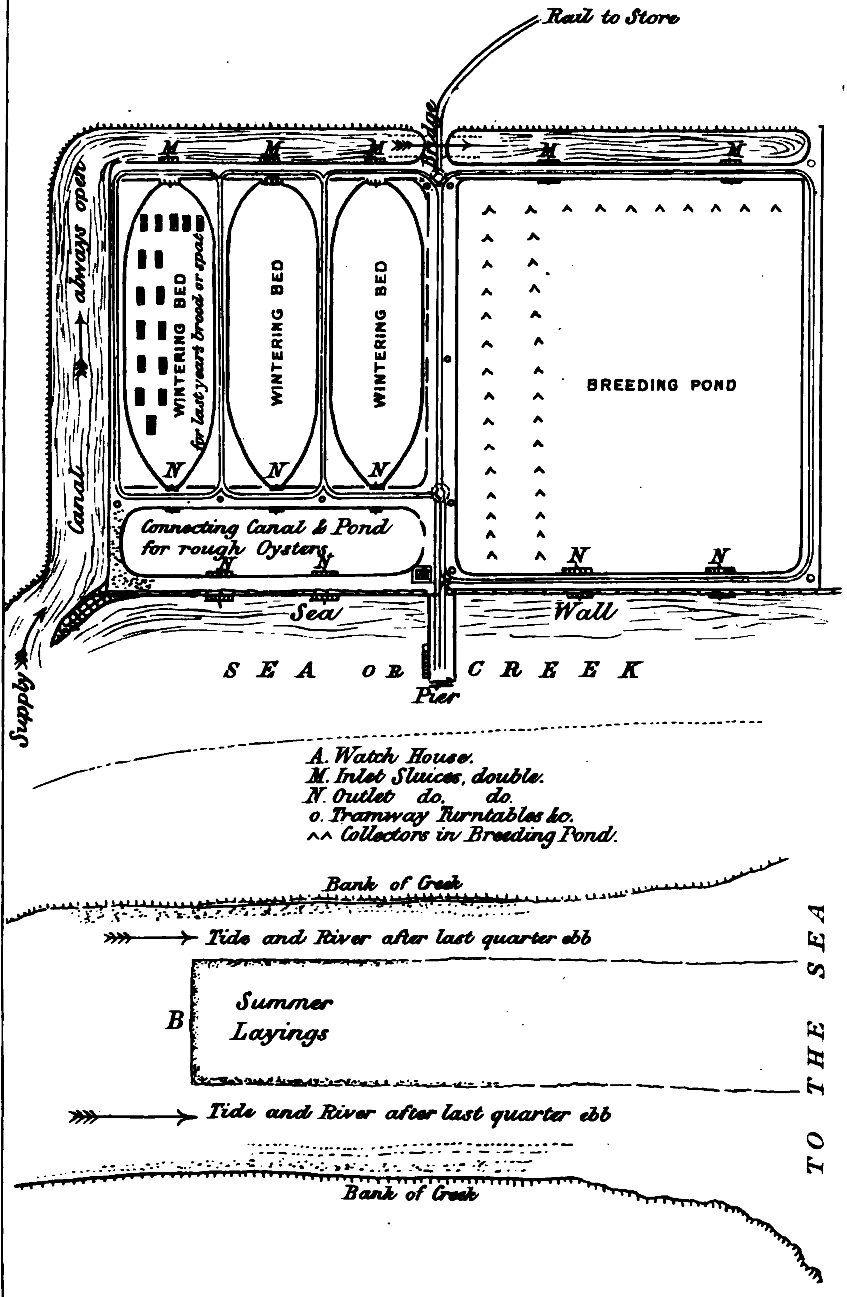
Besides this farm, there should be growing or summer beds, where they will have a fresh supply of water each tide, an acre of these beds being provided for each half-million oysters. They will then grow well and can be easily cleaned. When it is necessary to clean these ponds, the water is allowed to run off during the ebb-tide until only a few inches remain; the men will then work the harrows, allowing the inlet and outlet sluices to remain open; the running water will take away a good deal of the weed, slub, &c., and the rest can be easily removed by working a brush-harrow in the same manner.

The supply canal should be of sufficient depth to always retain water, the bottom of the ponds should be about the same level as low-water mark (neap-tide).

Summer Layings.

All brood, ware, &c., that are not going to be used for breeding, should be taken out of the ponds and placed on the summer layings before the end of May; the bed must

A MODEL OYSTER FARM.



A. Watch House.
M. Inlet Sluices, double.
N. Outlet do. do.
o. Tramway Turntables &c.
^^ Collectors in Breeding Pond.

not be subject to land drainage—a good plan to prevent this is to have a barrier (B, in plate facing page 330) across the stream, which will prevent the tide and river outflow, after the last quarter's ebb, going over the layings, as it will be then diverted into two side canals, the banks of which are the same height as the barrier.

A former writer has given eight men per acre as the number required to work an oyster-farm, but an estimate of this sort depends too much upon varying circumstances to be anything more than approximate.

The following are some of the conditions affecting this number:—

1. The quantity of oysters laid down to fatten.
2. The fertility of the year in spat.
3. The cleanliness of the grounds.
4. The market demand.
5. Necessity of removal to winter quarters.

The breeding-pond should be left dry all the winter, and water not admitted until the commencement of the breeding season. The breeding oysters should be placed in trays, so that they can easily be removed without disturbing the others. We do not recommend any fixed posts, wires, or other similar contrivances in the breeding-pond, as they collect weed, slub, &c. Channels should always be left between the rows of collectors, to allow a boat to pass when necessary to work at them. The collecting trays and frames may be of any moderate size, but about 2 feet 6 inches by 6 feet will be found the most convenient.

All the collectors should be ready before spatting time. Wooden collectors can be made, as shown in the sketch (Figs. *a*, *b*, *c*, in the plate facing page 332), so that the water can pass freely through them; they should also be coated with tar, and, after being dried, with a lime solution; they should be placed together, as a lean-to roof, at an angle of about 45°, secured by strong stakes driven into the ground on either side, and fastened together at the apex (Fig. *c*).

At Hayling Island, Mr. Dilnot showed us some canvas collectors made out of the stuff used for sugar-bags prepared in this way, which, he said, had been successful in 1881.

The canvas, after being dipped in tar, is carefully dried, to preserve it from the water, and, if used for a collector, is spread on a rough frame, and then coated with a solution of lime, clay, and sand, well stirred up together; lime and sifted earth would probably do as well.

For young oyster-holders or ambulances, Mr. Dilnot, at Hayling Island, has used the same canvas, when tarred and dried, nailed to the sides and bottoms of the battens which form the trays or boxes.

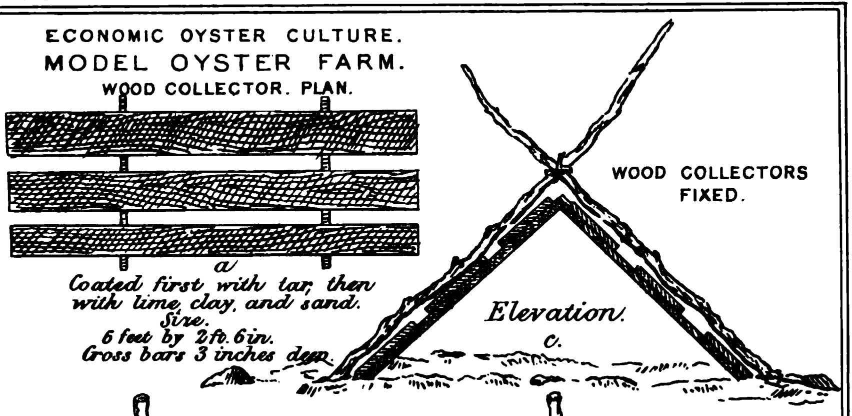
The advantages of wooden and canvas collectors over tiles, as used in England, is that the standing posts and wires are rendered unnecessary, and the operations of cleaning the weed and slub they attract are thereby dispensed with.

If tiles are used in stacks, as on some French breeding-grounds, it is obvious that all the ground between them is unoccupied by collectors, whereas the roofed collectors can be placed with their ends touching one another. Bearing in mind the immense fecundity of the oyster, one cannot have too many collectors on any given space of ground, consistent always with their being easy of access.

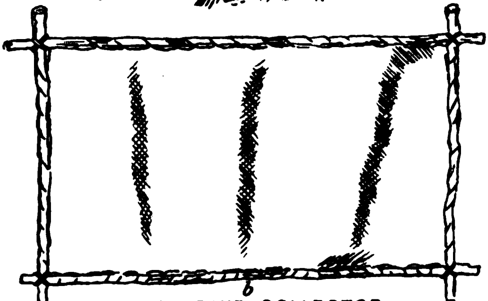
During the breeding season, the temperature of the water should be constantly observed. If the weather is too

ECONOMIC OYSTER CULTURE.

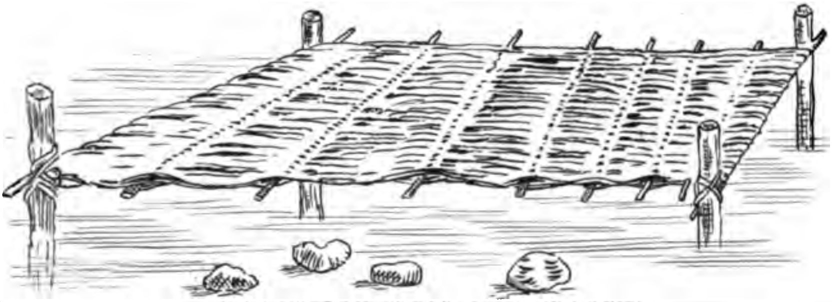
MODEL OYSTER FARM.



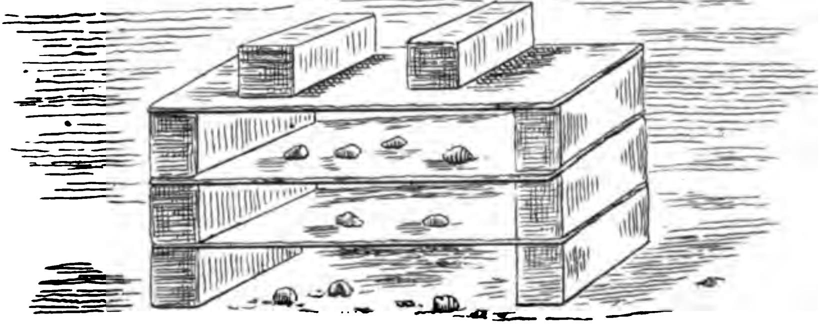
Coated first with tar, then with lime, clay, and sand.
Size.
6 feet by 2 ft. 6 in.
Cross bars 3 inches deep.



CANVAS FRAME COLLECTOR.



HURDLE COLLECTOR FROM M^r HART.



SLATE COLLECTOR FROM M^r HART.

warm, the inlet sluices should only be opened during the night tides; if not warm enough, they should be opened during day high-water.

During spatting time, it is an absolute necessity that water should be let in as much as possible, but as little as possible let out. Double sluices should therefore be fitted to each port of inlet, or outlet, which will allow the water to pass one way and not the other, as necessary. Before entering into the more general questions of breeding and fattening, we will give a list of some of the materials for the model oyster farm.

For collectors.—Coarse canvas, wooden frameworks, tar, wooden trays, stakes for securing collectors, tiles for filling up corners. A few wires and posts to rest tiles against, lime, clay and sand mixed together in a thick solution when used.

Ambulances.—Top and bottom trays fitting closely together, covered with coarse canvas and tarred, or similar trays, made of perforated zinc, &c.

Flat-bottomed boat, rakes, harrows, brush-harrows, dipping-tubes, for tarring and coating with lime, &c., cultacks, oyster-spuds, hand-distributors, tubs, wash-measures, dredging-boat complete for summer grounds, &c.

Oyster culture may be broadly divided into the two branches of breeding and fattening, which are distinct from one another. Each occupation requires peculiar conditions of site, climate and soil, and it is rare to find the circumstances favourable to both operations in one locality. The reasons for this are that breeding oysters require heat and tranquillity above everything, whereas the presence of the right sort of food in sufficient quantity is a *sine quâ non* for fattening purposes. When laid for breeding, oysters are not required to be fat; they want but sufficient nourishment to support life, which is always to be obtained in salt or brackish water. The physical conditions of a locality suited to fattening purposes—i.e. where there is a strong scour of the tide or a frequent inrush of river freshets—are most unsuitable for breeding, as the spat from oysters placed in such positions is frequently carried away and lost.

Speaking in general terms, we may say that the conditions prevailing in the districts devoted to oyster culture in France are most suitable for producing and rearing the young brood; whilst the English beds have the character of not only bringing lean oysters into condition for the market in the shortest time, but of producing better and more delicately flavoured oysters than any others in the world.

There are of course many oysters bred in England, and some fattened in France; but there seems to be little doubt that, whilst the colder temperature of an English winter contributes largely to the esteemed flavour alluded to, the higher temperature along the west coast of France is more favourable for the reproduction of oysters, and for the preservation of young during the first few weeks of their existence.

The main objects which the oyster breeder has in view are—

1st. To catch the spat, which would otherwise either perish or be swept away elsewhere.

2nd. To transfer the young oysters, as soon as possible after they are caught, to a place where they will be protected from their many enemies.

The oyster fattener does not trouble himself with the artificial means adopted for securing a large quantity of spat, although he is glad enough if spat happens to fall on his own grounds; but he generally looks to other layings, more favourably situated for breeding, to supply him with young oysters and those that require fattening for the market.

The growth and well-being of the oyster is then his especial care; and we shall endeavour to describe the various systems of oyster culture adopted, as local circumstances require special precautions.

The qualifications of a locality for successful oyster farming greatly depend upon the nature of the soil, both as regards its mechanical character and its chemical composition.

As regards its mechanical character, the best kinds of grounds are those where sand, marl, and clay are mixed in about equal proportions. If the locality be devoted to breeding purposes, the sand and marl may be in excess of the clay, as the grounds under these circumstances will be more readily kept clean. If they be required for fattening, the minute organisms which highly organic mud contains are so necessary for bringing the oyster into condition, that it is desirable to have the clay in excess of the marl and sand. Pure sand is prohibitive, and pure mud and pure lime are both disadvantageous for oyster culture, for reasons which we have more fully entered into under the head of "Inanimate Enemies."

As regards chemical composition, the soil of a locality, to be employed successfully as a fattening place, must contain more or less flocculent silt, highly hydrated, and rich in organic matter, i.e. in those microscopic organisms which are known as *Diatoms*, *Infusoria*, *Foraminifera*, *Rhizopoda*, &c., as the presence of these animalcules and *Algæ* are the true test of a good oyster ground. The soils of those places which have been successful as breeding stations always contain this hydrated silt in some proportion or other, but not necessarily in such large quantities as those places used as fattening stations. There is a general similarity to be observed in good oyster soils from various parts of the country.

Their usual appearance is that of a loamy alluvial mud, or calcareous plastic clay of a greyish-blue externally, but which, when caked and broken open, appears intensely black inside. Exposed to air, they oxydize rapidly, and turn of an ochreous tint, and when dry they form a friable mass. If washed, the materials of the rocks from which they have been derived are readily discernible: spangles of mica, felspar, and hornblende bespeaking an igneous origin, as fragments of shell and particles of sand point to the Eocene beds for their origin, whilst a preponderance of *Foraminifera* and *Globigerina* indicate a cretaceous derivation.

In some places, as at Marennes, there is a shelly loam, called in France *sable vazal coquillé*, which possesses excellent fattening properties. In Mesozoic times the Purbeck beds must have been wonderful oyster grounds. The influence of the soil upon both breeding and fattening, as shown above, is complicated by many other circumstances, some of which we have entered into in our chapter on deep-sea cultivation. Velocity of tide, angle of dip of shore, temperature and depth of water, are amongst the most importance of these.

Breeding.

The starting-point of the oyster breeder is obviously the act of laying down mature oysters to spat. It might appear to the superficial observer a very simple thing to dredge up oysters from other beds and lay them down to breed, but nothing is easier than to commit grave mistakes at the outset.

It used to be considered that oysters would not spat after having been moved any distance, but the latest information received on the subject leads us to think this is an error. Removal may hinder, but need not prevent, subsequent fecundation. The after-health and well-doing of the oyster depends in a great measure on the time of year at which it is moved; the best time being between November and March, as it may be taken as a general rule during the period of reproductiveness that, with one exception hereinafter mentioned, *the longer the period between the time that oysters are laid down and the time of their spatting, the greater will the chances of reproduction be.* Nothing can be more injurious to the oyster than to move it whilst it is sick, as, apart from the loss occasioned by the death of the young about to be produced, the damage to the constitution of the fish itself is so great, as to make it improbable that oysters so treated will ever spat again. It may seem extraordinary to state after this that it has been lately found advisable to place *deep-sea oysters* in breeding ponds as short a time before spatting as can be arranged. The reason for this may be that the difference in pressure between a few feet and perhaps thirty fathoms is so great, that if you gave the oyster time to think about it, it would, under these conditions, refuse to spat at all. But being taken up in an advanced stage of pregnancy, it cannot help itself, and rids itself of its burden as soon as it can; of course a much larger proportion of immature spat is produced under these circumstances than under normal conditions.

Secondly, great care should be taken of the oyster during removal, by protecting it from wind and consequent evaporation whilst it is out of the water. When first dredged up, oysters should be picked out of the accompanying rubbish, cleaned, and covered with sea-weed in a cool place.

No longer delay than can be avoided should take place before they are relaid, and when they are out of the water for more than twenty-four hours, sea-water should be thrown over them occasionally.

Deep-sea oysters spat most freely in shallow water, i.e. in water of which the average depth at half ebb is from four to six fathoms; below this depth the difficulties of reproduction increase with the distance from the surface, and it is doubtful whether spat is ever *produced* at a greater depth than thirty fathoms, though of course it may drift and fall there from shoaler water. The change, therefore, from deep to shallow water should be accomplished gradually (except in the one instance already mentioned), so as to accustom the oysters to the new conditions.

This gradual acclimatization should be carried out further with oysters which have to be moved any distance. If unaccustomed to be left uncovered at low water, they should be raked or dredged in, and dropped first to a point between low spring and low neap-water mark, and later on to above the latter line, being moved a few feet further inshore every third or fourth day. After the oyster has been left uncovered for an hour or so every day for a week, it begins to know when the ebb-tide commences to run, that the time for its exposure is approaching, and it takes in an extra quantity of sea-water to last it till the flood begins to make. If the distance from high-water mark be gradually decreased, the oyster gets accustomed to remaining out of the water longer and longer every day, till at length it will imbibe and retain sufficient salt water to enable it to keep alive during a journey of a fortnight or more, if proper care be taken during transit. To travel any distance successfully, oysters require careful packing. All dead and diseased ones should be removed, and the healthy ones, after being well cleaned from outer growth, should be placed in a tub or barrel, with the *round shell downwards*, packed tightly, and covered with a layer of fresh sea-weed. If practicable, sea-water should be thrown over them once every twenty-four hours.

Supposing that a fair stock of parent oysters has been secured on the breeding beds, and laid down at the proper time with the precautions we have recommended, the next thing that will occupy the attention of the breeder is how to secure the greatest number of young during the ensuing summer.

The absolute necessity of providing the young spat with some clean substance to adhere to soon after it leaves the parent shell, has given rise to the custom, from time immemorial, of placing collectors in the water near the parent shells. The shapes, sizes, positions, and arrangement of these collectors have been countless, as are the materials of which they have been made. Stones, tiles, wood, faggots, shells, furze bushes, hurdles, hampers, slates, wattles, &c., have all been used indiscriminately and with varying success.

The actual composition of the collector has very little to do with its attractive power for oysters, as it appears that they do not derive any nourishment, even in a shell-constructing point of view, from the material to which they are affixed.

Collectors.—Fascines.

It was from Lake Fusaro, where they have been employed from time immemorial to intercept the spawn, that M. Coste first obtained his idea of faggots as collectors. He introduced them to the French fishermen, and they were used, with great success at the outset, at several places on the coast of

Brittany; they have also been tried at Herne Bay, Brading, and other places in England.

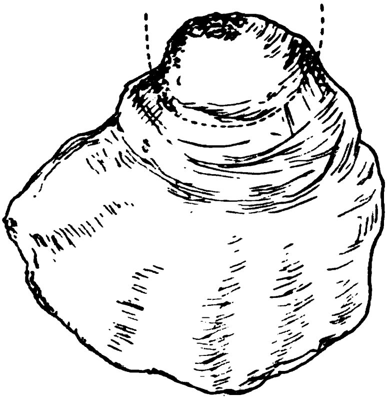
The "fascines" should be slung on ropes or wires, attached to posts, and fixed in rows along the foreshore, the bundles being supported some two or three feet above the oysters which are scattered beneath them. The wood composing the faggots should be hard and dry, and cut at least twelve months before it is used for this purpose. Furze has also been tried, and has been found to answer fairly well. Its cheapness is a recommendation in its favour.

The advantage claimed for fascines as collectors when first introduced in modern times, was the ease with which the oysters could be detached from them. At this time stones were the only available substitutes, but now that improved collectors have been introduced, fascines are rarely if ever used.

They are totally unsuited for any place where there is a tideway running, as in such localities they act far more effectually as collectors of weed and floating rubbish than of oyster spat, even when the resistance they offer to the current does not result in their being carried away altogether. Another disadvantage is the rapidity with which they become slimy and covered with weed; when in this state they are utterly useless, as the spat will not adhere to the wood unless it be perfectly clean. Probably this is one of the causes of the failure of the extensive experiments carried on in the bay of St. Brieuc. Those who had charge of the undertaking do not appear to have paid sufficient attention to keeping the culch and collectors clean, and defective falls of spat resulted.

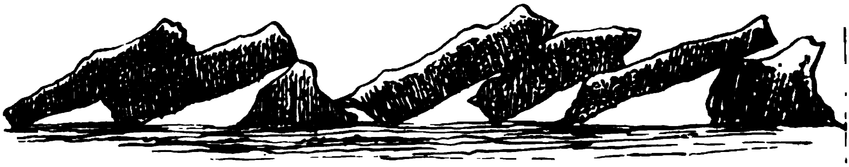
It has been said that oysters have a tendency to conform their shape to that of the object to which they are attached,

Natural Size.



GROWTH IN TRAYS. N. HAYLING.

Outside dotted Curve, from May 1882 to April 1883.
Inside from July 1881 to May 1882.



Plan of arranging Stones as collectors at the Ile de Ré.

and those fixed on twigs certainly appear to grow in a somewhat elongated mussel-shape. This malformation corrects itself, however, when the bundles are broken up and the young brood separated.

Another great disadvantage attaching to all wood collectors uncovered by cement is that it is impossible to remove the young oysters from them without great risk of damage to the shell, until the latter has become hardened by at least two winters' growth.

Hurdles

Are used in some places to catch spat. They are supported in an horizontal position by a stake at each corner, and placed about two feet above the oysters. Their use, however, as well as that of sides of hampers and other makeshifts, has been superseded by cemented tiles, and in the most advanced oyster farms by other forms of collectors, coated with a solution of lime.

Slates,

Arranged in parallel horizontal layers, and kept apart by bricks, are used in some parts of France; they, like tiles, can be covered with cement, but their expense is against them.

Stones,

At the Ile de Ré, and at Oléron slabs of stones, from 18 inches to 2 feet long, by 9 inches or 80 broad, are placed in rows canted up one against the other, as shown in the sketch opposite. Series of stones so arranged are made about 100 feet long, and four or five of them are grouped together, within a space about 30 yards square. The walls of this enclosure, called a "parc," are constructed of slabs of stone placed upright, and made watertight by being coated with a coarse cement made from mud found close by. The cost of a parc of the above dimensions is about 800 francs.

Stones are about the worst sort of collectors that can be used. They are heavy to move, difficult to clean, and the oysters are liable to injury when being removed from them; but as they are not expensive, entailing no cost but that of manual labour, they are suited to the exigencies of those districts where labour is cheap.

Similar constructions are erected at Oléron; but here, contrary to the custom adopted at Ré, of laying down parent oysters in the parcs, they trust entirely to the spat being drifted in from the natural banks outside. Like arrangements of collectors, slightly modified according to local circumstances, may be seen in work at Chatellion, and at a few places on the west coast of Ireland.

Tiles.

After long experiment it has been found that a good kind of collector is the common house-tile covered with a coating of lime. This form was first suggested by Dr. Kimmerer, and consequently the name of "Kimmer tiles" has been given to them. His invention consisted in laying a piece of damped paper on the tile which, when covered with cement, was easily protected from sea-water; both paper and lime was then easily removed by the "cultack" (a knife used for the purpose of separating oyster bundles and detaching them from collectors), the tile being thus preserved for future use. Before Dr. Kimmerer's invention, the tiles used to be broken up by pincers, it being deemed preferable to sacrifice the tiles rather than risk damaging the young oyster by removal. This plan is not yet wholly abandoned; as in the Morbihan, where the authorities do not, as at Arcachon, put an embargo on the sale of oysters under five centimeters in diameter, it is the custom with some cultivators to break up their tiles into four or five pieces and sell them thus, with brood attached, for laying down elsewhere. These potsherds are called *huîtres à tessons*, and are eagerly bought by many owners of fattening establishments, as they partly dispense with the use of ambulances for the protection of the young brood ; crabs and other vermin being unable to attack them with the same facility when attached to tiles as when they are single. Oysters grown in this fashion are not exposed to the danger of injury during removal from the tiles, but, being crowded together, do not become so well formed afterwards as their earlier liberated brothers. The idea of these *huîtres à tessons* originated with Dr. Gressy.

Dr. Kimmerer's invention of applying paper before the cement has now given way to an easily detached mixture. The tiles are coated with common lime and water, and with hydraulic cement. At Auray the hydraulic lime is applied first, at Arcachon the reverse. Tiles are cheap in France, hence their widely extended use. The average cost is £2 per 1000, or about a halfpenny each, and there are more than ten million in use on the *crassats* at Arcachon.

The time for placing them in position varies according to climate and locality. At Arcachon they are laid down about the 1st of June. At Auray the spatting season is fully a month, and sometimes six weeks later ; so the tiles are not in position much before the middle of July. But these dates, of course, depend a good deal on the season. The bottom of the sea in the immediate vicinity of the tiles is generally strewn with clean culch.

The methods of arranging the tiles depends upon the position in which they are placed. In the large flat parcs at Arcachon they are placed in rows or patches on the beds which are dry at low spring tide. The tiles are laid in stacks, crosswise one row above another, till the height of three or four feet is reached ; they are then secured from the run of the tide by stones and stakes. The weed around them is hoed away for a few yards, and the oysters are laid down. The growth of the long weed (*Zostera marina*) is encouraged on these flat beds, as it serves to protect the oysters from the sun in summer. The greater portion of the spat is found adhering to the under surface of the tile. It is an unsettled question as yet whether this is merely because the concave surface is cleaner, or whether the oyster does or does not spat most often on the flood tide, in which case the spat would adhere in rising.

The tile crates are erected about every twenty yards, and arranged alternately, or, as the French say, *en quinconce*, so as to break the flow of the tide evenly and thus catch most spat. The top of the crate is often protected by planks coated with pitch, on which culch has been strewn before it is dry; these coverings often catch a lot of spat. Where there is no tide, or the ebb and flow are equal, it is recommended that the tiles should be placed at an angle, as they have then been found to attract the greatest quantity of spat. The system of laying down tiles has been abandoned at Auray on account of the rapidity with which they become covered with mud.

M. Leroux has substituted a plan of suspending the tiles on an iron wire, which is firmly strung between two posts fixed in the ground. This seems to answer well, and has the further advantage of being easily taken up and laid down ; twelve or fourteen tiles are thus placed on one wire.

Ruches

Are arrangements of tiles round about a stake, and serve the same purpose of keeping them off the mud as the last-named arrangement.

Chaplets

Are bunches of oyster- and cockle-shells, strung on wires, and suspended in the water as collectors; they are very successful in attracting spat.

The foregoing remarks have partly been derived from experience gained on French beds, as attempts at artificial breeding in England have not been altogether satisfactory.

Attention in England was first drawn to the subject in 1865 by a magazine article describing M. Coste's experiments on the French coast, and the original attempts to imitate them were made at Hayling Island by Mr. G. F. Hart, to whose intelligence and enterprise must be attributed whatever measure of success has been attained in Langston Harbour. After visiting the French beds, and being convinced that one of the great causes of failure of many of the experiments was the exposed situation selected, he proceeded to apply the same system to the quiet waters surrounding Hayling Island. The results were at first very satisfactory, over 128 million of oysters being deposited on the 10,000 hurdles placed in the old salterns as collectors. The breeding establishment is still kept up, though the result originally expected has not been attained.

Nurseries have also been tried at Herne Bay, Reculvers, Brading, Newport, Lymington, and at Nacton; but the use of collectors as employed in France does not seem to have taken root in England, and most cultivators seem to depend mainly upon their culch for catching the spat.

Culch (sometimes spelt "Cultch")

Is the name which is given to the débris of shells, stones, &c., which is found at the bottom of the sea, on or near oyster beds. It has been the practice from time immemorial* to supplement the natural supply by throwing down deposits of this sort on oyster grounds. Oyster- and cockle-shells make the best material for this purpose; in default of this, stones and pebbles may be used, the great point being that the culch, whatever it is composed of, should be clean, and for this purpose the shorter the time it is laid down before the spat falls the better. *Culch-boards* are two pieces of wood, generally from the head of a cask, which are used by dredgermen for taking up and throwing overboard the old shells, débris, &c.

The collectors are left with the young oysters upon them until the latter have attained the size of a sixpence, when they are removed and placed for protection in boxes called "ambulances." These cases are generally wooden frameworks, with wire or perforated zinc covers and bottoms, of which the meshes must be small enough to protect the young oysters from the depredations of their enemies.

From 2000 to 5000 oysters are placed in each ambulance, which varies in size according to the fancy of the grower. When filled, they should be placed in the water at varying depths, but always supported a few inches off the bottom so as to allow a free circulation of water to go on round the box. Some proprietors place them in their parcs, others on the shore, as near low water-mark as possible.

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* We were rather amused to read in the papers the other day of the "wonderful" discovery made in America, that old oyster-shells were useful for breeding oysters.

It is considered desirable to place them in a current, or as near to one as possible, as their growth is much more rapid under these conditions. In fact it is astonishing how quickly oysters will grow when placed in favourable circumstances. The wire-covered ambulances referred to above cost about twenty francs each. The canvas ones probably about four shillings.

In France, when oysters are old enough to be moved, i.e. when they are about eighteen months old, they are transferred from the breeding parcs and laid down to fatten in the "tidal" *claires* or *crassats.* And here we ought to explain that the term "parc" is more strictly applied to a shore or bank where parent oysters are laid down and collectors are placed to arrest the spat. A *claire,* on the other hand, is a tidal enclosure, provided or not with sluices, where the young oysters are put to grow and fatten; and a *crassat* is an ebb-dry foreshore mudland, corresponding to the banks of some of our creeks. *Claires* or clears are not employed so frequently in the United Kingdom as in France, their place being supplied by foreshore and creek beds, the latter producing some of our best Native oysters.

The oysters are moved into ambulances from the parcs at Arcachon in October, i.e. about fifteen months after they are born. At Auray they are allowed to remain till the following March or April before being taken into *claires.* When the transfer takes place, they are taken off the tiles by women, who can easily remove them with a cultack.

The result of our inquiries and experience is, that young oysters should be removed as soon as possible after the spatting season has ceased. *The earlier they are removed, the better their chances of growth and healthy existence.* With the present easily friable coating of lime, &c., there should be no difficulty in removing an oyster from its first bed after it has laid there three months.

Fattening.

The system of working beds which are never uncovered is much less laborious than that required on ebb-dry mud-banks, inasmuch as the oysters do not require to be moved in the winter for protection from frost. There is, however, constant employment on a large oyster farm of any kind, as an account of the operations of the Whitstable Company will show.

The Whitstable Free Dredgers' Oyster Company is managed on co-operative principles, and affords employment to a large number of people who must be free dredgers of the town, born and bred. The members themselves number about 400, though the collateral industries to which the business of the company gives rise afford employment to over 3000 men, women and children. The actual business of the company consists in purchasing brood, half-ware and mature oysters, and laying them down to fatten. Very little is done, as in France, by way of breeding, for Whitstable, though undoubtedly one of the best oyster-fattening grounds in the world, is not a good breeding place, being too much exposed to the effects of easterly gales for heat and tranquillity to prevail at the critical time of year.

From August to May the boats are employed dredging for the market two or three days in each week, in which operation a certain quantity called a "stint" is assigned to each boat; this it must complete, but not exceed. The other days are devoted, as necessary, to cleaning the ground of vermin, laying down, and shifting oysters from one part of the ground to the other.

From the 12th of May to the the middle of June the boats are busy for five or six hours every day, removing all oysters that will be ready for the market by the end of the summer from the breeding and growing beds to the fattening grounds. At the same time the ground is cleaned and prepared as far as possible for the coming fall of spat.

From the middle of June to the 4th of August, i.e. during the spatting season, the beds remain untouched, and the fishermen are employed yachting and in other seaside vocations.

In former years the company trusted greatly for its supply to the spat of its oysters floating on to the common ground, known as "The Flats," where the small oysters were dredged up and sold to the company to be redeposited upon their grounds; but of late years this supply, although continued, has become wholly insufficient, and they have been obliged to seek their brood, &c., elsewhere.

The principal sources of the present supply are the Pont, the Essex rivers, viz. the Blackwater, Crouch, Roach and their tributaries; the basins of Arcachon and Auray in France, Schleswig in Holland, the Skelling Bank off Heligoland, and various places in Scotland and Ireland. The prices paid to dredgermen for oysters found on the Flats were last year as follows:—

All mature oysters of whatever kind, 13*s.* per hundred (1800 to 2000 to the bushel); brood or half-ware (which run from 3000 to 6000 to the bushel), 6*s.* per hundred. The cost of oysters from other parts varies with the state of the market.

Oysters, both mature and immature, from Arcachon and Auray are laid down at Whitstable in large quantiti

They are locally called "pearls," and after a short time become almost identical in flavour to the Native. Twenty-eight million were imported in 1880, and there is no reason to suppose that the supply has fallen off during the last two seasons. It may, indeed, be shrewdly suspected that the true British Native, if not doomed to extinction, is, like the black rat, becoming rarer and rarer every year, its place being supplied by French oysters which, when placed under the same conditions as Natives, rapidly acquire both the flavour and growth of the indigenous variety—appearances which, if not exact, approach the mark nearer and nearer each generation.

All oysters, other than Natives, laid down in the Thames Estuary rapidly strike out a fresh growth, the new shell being plainly discernible from the older growth ; and whatever the "*provenance*" of such oysters be, they all more or less resemble Natives after a time, in shape, flavour and texture of shell, the resemblance being greater the longer the oyster remains in the beds. And it is now affirmed by some persons that it requires but a few generations to turn not only ordinary oysters but also Portuguese Gryphœa into Natives. This statement, however, remains yet to be proved, and we believe that it is as difficult to eradicate the "mark of Cain," i.e. the black spot out of the shell of the Gryphœa, by natural selection as it is to make the leopard change his spots.

A large number of the oysters originally imported from Arcachon and Auray, and laid down to fatten at Whitstable in February or March, are removed during the ensuing autumn to Hayling Island and other places on the south coast, where the climate is milder, to winter, as it has been found by experiment that the French oysters are less hardy than Natives. Most merchants try to sell their stock before the winter; but where they are unable to do so, they are obliged to take these precautions to preserve them. It is as yet undecided whether French oysters are sufficiently hardy to stand an average winter at Whitstable, Faversham, &c. The loss from them is undoubtedly greater than from Natives, but the question is whether the cost of removal is compensated for by preservation of life. It is a risk; in such a winter as the last it would probably not be worth while to move them, but in such a winter as that of 1880-81 the saving would be enormous. It must be borne in mind that after a hard winter the frost often breaks up with a gale of wind, and the oysters, being then weakened by the cold, either succumb to the sand, or get broken by being knocked about by the ground swell.

Another company of dredgermen which is self governed is that of the Colne Fishery. It consisted in 1876 of about 400 members, and about 200 fishing and dredging smacks were either hired or owned by the company. The fishery is about six miles in length, and at the lower part two miles in width. The quantity of oysters obtained from the company bears but a small proportion to the yield from private layings in the Colne and Blackwater. There are more than a hundred of these layings, some freehold, others copyhold and held from the lords of the manors.

The Colne company used to pay a higher rate of wages than the private owners, on the principle of the larger the fishery, the more it can afford to pay its workmen.

All the Colne and Blackwater oyster grounds were more or less successful in obtaining spat in 1881, the cleanest beds of course obtaining the greater share, whilst the uncultivated beds obtained very little. About ten per cent. of these oysters may be marketable in 1883 when the oyster season commences, and, though the price may increase, there ought then to be a fair supply of real Natives in the market.

As an example of the second class of laying, viz. that which is uncovered at low spring tides, we will describe the system of cultivation adopted on the Essex Creeks; and to illustrate the tank or enclosure system we shall refer to the celebrated establishments on the river Seudres.

Cultivation on the Essex Creeks.

On the Roach, Crouch, Blackwater, and their tributaries, oysters are stored during the winter in pits at the side of the river, the different sizes and qualities of oyster being kept separate. The pits are roughly constructed dams, about 10 feet square, and are covered only at spring tides. They are from 15 to 18 inches deep, and are provided with sluices, by which they can be emptied at low water for cleaning purposes. At some places these sluices are made self-acting, permitting an inflow of water, but barring its egress, and arranged so that the water shall be changed every tide. Oysters are generally moved into the pits in October and November, for protection from frost, and also that they may be obtained conveniently when required for the market.

The protection thus afforded to oysters is very considerable. They are not exposed, either to being left uncovered by the tide or to the danger of cold currents coming down the river. Floating ice does not ground in these protected spots, though of course it forms over the pits during severe frosts. Ice has been known to be 6 inches thick and the oysters beneath uninjured, in fact it is then a protection.

One of the most necessary and arduous duties in oyster culture in winter is keeping the ground which is uncovered at low springs clear from oysters. Merchants generally shrink from the labour of moving all their stock into pits, even when they have enough accommodation for them, and those which are left in the river are liable to be killed by frost, or "carted away" by floe-ice. If there happens to be a continuance of easterly winds and a high barometer during spring tides in winter, the water in our estuaries will frequently fall below the low spring-tide water-mark; then the oysters laid there will get nipped by the frost unless quickly removed into deeper water.

Floods from melted snow are particularly dangerous; fresh river water alone is sufficient to kill oysters, and so, of course, fresh-water and cold together are doubly disastrous. Many hundreds of pounds' worth of oysters have been destroyed by being placed too far up a creek, where the land floods were so powerful that the flowing tide could not dilute them. At Paglesham, Mr. Wiseman says he has known the water of the Roach sweet enough to drink during strong freshets.

The oysters are taken out of the pits in March or April, and laid in the bank of the river to grow and spat. If kept in the reservoirs during the summer, but little spat is secured from them, as there seems to be too great a variation in temperature, during the summer, between day and night in these shallow pits. In the pits at Brightlingsea, an attempt was made to get the oysters to spat, but very little fell, and that which did fall was all found on the shells of the parent oysters, by which it seems that animate culch is less affected by the variations of temperature than inanimate matter.

When laid again in the bed of the river at Brightlingsea, the oysters are distributed on the mud, between low neap and low spring water-marks. They are deposited by hand, being shot out of flat trug baskets without sides, and it requires no little dexterity to strew them evenly in this manner. Dredging and harrowing are then carried on during April, May and June, and in some places proprietors continue this work right through the summer. It is as yet an undecided question amongst oyster farmers on the east coast whether the increased cleanliness imparted to the culch by continued dredging through the spatting season compensates for the loss of tranquillity to the breeding oysters. It probably depends upon the amount of mud in suspension in the water at any particular locality. There is a doctrine prevalent amongst a number of oyster growers that dredging is good for the oyster during the time it is spatting, as they say that it requires oxygenating at that time, which effect dredging produces. We very much doubt, however, whether any of the higher animals would care to be dredged upon during a similar interesting state.

Oyster breeding on the Roach river promised to be very successful at one time, but the laying down collectors had to be abandoned owing to the damage done to them by passing barges grounding on the sides of the river. All that is now done is to strew clean culch along the sides of the river, both above and below low-water mark, oyster-shells and cockle-shells from the Nore being most in repute.

During the process of dredging the contents of each haul is carefully picked over and sorted: the bundles are separated, the dead and diseased oysters removed, or cleaned if only affected by outside growth, and mussels, starfish, and vermin of all kinds brought ashore and thrown away. When returning the healthy oysters to the water, they are sorted as far as possible, so as to be more readily got at during the coming season. Oysters separate much more easily in summer than in winter. If the cultack be freely or carelessly used during the cold weather, oysters are apt to rob one another, i.e. to tear away pieces from each other's shells.

The Whitstable people have an idea that constant dredging tends to fatten oysters by bringing them into contact with a wider food area, but this opinion, we think, is not contrary to that of the most experienced Essex merchants.

Tank System of Cultivation.

The parcs at Marennes are situated on both sides of the river Seudres ; they are not, like those at Arcachon, submerged every rise and fall, but only at high spring-tides. Each claire, or tank, is about thirty yards square, and they are so arranged that a certain number can be laid aside for cleaning whilst the others are in use. The walls for retaining the water are low banks of earth about five feet thick and three feet high. The tide is admitted by water-tight sluices, as it is considered most essential to be able to regulate the inflow and outflow of water with the greatest exactitude. A trench is cut on the inside of each pond so as to collect the green slime necessary for the production of the green fins, and some considerable trouble is required before the tanks are fit to receive the oysters.

The preparation of a reservoir for the reception of oysters, called in French *le parage*, takes place in March. It consists of two operations : 1. Called *le gralage*, which, when converted into an English agricultural term, means the *lying fallow ;* and, 2. *La mise en humeur*, or the after-cultivation. The object of allowing a pond to lie fallow is to purify the soil by evaporation and oxidation.

The water is allowed to run out of the reservoirs, which are then quite dry, except at high spring-tides. Under these conditions the mud dries and cracks in the same way that a ploughed field breaks up after a winter's frost. The protoxide salts get turned into peroxides, and any decaying organic matter that may be in the mud is rendered innocuous. As the result of two months' exposure of this kind, the surface is covered over with a new layer of fine desiccated mud of a fresh and purified nature. The second part of the operation is then undertaken, and a small quantity of water is admitted into the enclosure, just enough in fact to cover it entirely. The dry crust at the top of the mud then slakes and, as it were, effervesces in doing so; the final result being the deposit of a fresh layer of mud of uniform thickness over the whole of the basin. This creamy layer the French call *humeur*, and the diatoms contained in it are supposed to be rendered more digestible by the operation. The whole operation occupies from six weeks to two months. The oysters are then placed in the tanks thus prepared, and begin to turn green in about a fortnight, though the longer they are left, the better flavour do they acquire.

The number of oysters laid down depends upon the time it is intended to keep them; for as the food supply is limited in those ponds where the water is not changed very often, of course a small number will fatten more rapidly in a given space than a large number; the average number is about 6000 on an acre.

The oysters are generally from twelve to eighteen months old when placed in these greening claires, and they remain there for two years or so, growing and fattening; during this time they should be shifted from one pond to another to ensure successful results. Many, however, remain in the ponds a much shorter time, as it is often the practice to place mature oysters in these parcs for a few weeks to acquire the green beards, which they do at a comparatively cheap rate, though they do not acquire the flavour of those oysters that have been in the ponds their usual time.

We have already referred to the cause of the green-finned oysters under the head of Natural History, but in consequence of the groundless prejudice which exists against them in England, and which is the cause of the exportation of all our Essex green beards to Ostend, we think it desirable again to state that this colour is caused solely and entirely by vegetable matter, and is not only quite harmless, but imparts an exquisite flavour to the oyster.

Oysters and other molluscs undoubtedly do absorb and retain copper in their tissues when placed in solutions containing it; but in every case that has been looked into, and many experiments have been conducted by competent analysts with reference to this matter, the copper has been found in the body only of the oyster which is coloured bluish-green, and not in the beard which was not green. In green-bearded oysters the body of the fish is of the usual or of a very slightly greenish tint, and has never been found to contain a trace of copper.

Before leaving this part of our subject, we are tempted to remark that, *in theory*, oyster culture seems so simple a thing, that the wonder is there are so many failures at it. But when we come to put our theory into practice, we begin to find how many local circumstances there are, apparently trifling in themselves, but which really exert a powerful influence on our calculations; and it is only by many years of watchful observation that any one can acquire sufficient experience to be able to understand,

and to cope with the numberless difficulties which will beset the path of an oyster grower. If, however, we were asked to sum up the principles of oyster culture in as few words as possible, we should say—Keep your culch clean, keep down the vermin, separate from the collectors as soon as possible, protect from frost during the winter, keep the oysters quiet during the spatting season, and pray for calm and warm summers!

CHAPTER V.

LAWS AND SUGGESTIONS FOR THE PROTECTION OF THE OYSTER FISHERIES.

Dredging v. *Over-dredging.*

Oyster culturists and experts are divided into two schools with regard to this question. The views of one party are fairly represented by the Report of the Select Committee appointed by the House of Commons in 1876 to inquire into the scarcity and consequent high price of oysters; whilst the other side are represented by the Royal Sea Fisheries Commission Report of 1866.

The desirability of keeping oyster-beds clean by dredging is so intimately connected with the general question as to whether their productiveness is injured in the process, that it is impossible to discuss the matter without going into the controversy fully, and before summing up the evidence, we think it desirable to state briefly both sides of the case as fairly as we can.

The opponents of over-dredging contend that a close time should be observed, because—

1. Overwhelming evidence is forthcoming in condemnation of excessive and reckless dredging.

2. The oyster-beds of Poole, Granville, and Cancale, amongst others, have been totally destroyed by over-dredging.

3. Several beds in the Channel have been destroyed shortly after discovery, being pounced upon by dredging-boats, who, working with the wind abeam, with their boats almost touching one another, have dredged up nearly every oyster on these beds.

4. That as on deep-sea beds the oysters lay in streams, any that are by chance left after a visit from the dredging-boats must have been disturbed, and will not afterwards spat productively.

5. That on the public grounds fishermen invariably throw overboard again the enemies of oysters that are not either eatable or saleable: thus dog-whelks, cliona, and five-fingers are neither destroyed or brought away from the beds, the undiminished supply of "wolves" being left to prey upon the few "sheep" that remain.

6. The constant operations of dredging cannot be necessary, because extensive layers of oyster-shell, many feet thick, are found in various parts of the world, proving that oysters flourished prodigiously long before dredging was thought of. If they had been then subject to the disastrous results which are stated to arise from abstaining from dredging, they could never have survived. The great ocean beds, which have never been dredged, also support the theory that oyster grounds can thrive without any aid from man.

7. Laws are necessary for the preservation of any animal which serves as food for man, whose habits compel it to live in a confined area to which man has access.

8. Over-dredging is the cause of the scarcity of young oysters on public grounds, the brood being taken before it is fit to be removed, the shell being as yet so soft that it is injured in the process.

9. If the Boston oyster-beds were spoilt, as some people say, by being closed, it was because, after being overworked, they were closed for too long a time. If they had been subjected to periodical inspection, it would have been found necessary to clean them, but not to dredge up any oysters.

10. Dredging diminishes the number of oysters, and hence there are less to spat. How can dredging be productive of tranquillity?

11. The native grounds have been over-dredged since the great spatting year of 1858, hence the present scarcity.

12. On restrictions as to a close time being enforced at Emsworth, the takes by the Oyster Merchants Company there increased from 32,210 in the year 1871–72, to 380,744 in the year 1874–75.

Now the advocates of dredging at all times argue that all restrictions should be removed, because—

1. Over-dredging has *not* been the cause of the decreased production of oysters. The decrease has not arisen from any cause over which man has control, but from a general failure of spat occasioned by the inclement seasons of the past twenty years.

2. The beds at Poole, Cancale, Granville, &c., are special cases acted on by local circumstances only, and do not prove the rule.

3. Oyster grounds cannot be dredged *out.* One bushel only left on a ground during a good spatting year would be sufficient for an enormously increased supply.

4. That it does oyster grounds good at all times to be cleansed from weeds, mud, and vermin.

5. That in the estuary of the Thames five-fingers are always kept and sold for manure. That dredging disturbs and disperses the enemies. In fact the injury inflicted by allowing the enemies to prey unrestrainedly on the oysters is greater than that which any amount of dredging can accomplish.

6. From the fact of the layers of oyster-shells being superimposed one on the other, it may be assumed that

each bed only lived a short time comparatively. The deposit of sand and clay, &c., which is frequently seen between the layers, points to the cause of death, and judicious working might have removed this. Further, each bed must have been defunct before the next could have been deposited.

7. Man's influence is so slight when compared to the immense operations of nature either for beneficial or destructive purposes, that it may be practically left out of account when considering the question of the supply of fish and molluscs.

8. As spat is always deposited in an over-crowded state, if some of the young brood are injured by removal, those that remain are benefited by the increased space given them.

9. At Boston the corporation obtained an order from the Board of Trade empowering them to close the beds for three years. Before the clôture took place, the boats had been able to get as many as 1000 oysters a day. When the beds were re-opened, a boat could with difficulty get fifty in a day's dredging, and the grounds were found to be ruined by the accumulated rubbish.

10. During the five years which followed the great spatting season of 1858 there were more "Natives" dredged off the grounds than were ever known before, although during these five years there was a general failure of spat. Therefore the supply of oysters has nothing to do with the failure in spatting, provided that a few are left to breed.

11. In 1857 there was a large fall of spat on the Native grounds, and a great many boats dredged every day, weather permitting; yet in 1858 double the quantity of

spat fell. At Swansea fifteen miles of ground has been shut off for a nursery, except for three months of the year, under a regulating order of the Board of Trade ; but oysters have decreased there by more than a third.

The foregoing evidence might be amplified on both sides, but we have said enough to show that there are difficulties in deciding the question satisfactorily to all parties ; as in most other debateable points, there is a good deal of truth in the views of both disputants. The essence of the matter appears to us to lie in the fact that the same system of cultivation and treatment cannot be applied to all oyster-beds. There are many beds that certainly require human care and attention, whilst others can be trusted to take care of themselves.

If the grounds are situated where they are liable to become rapidly silted up, as is the case with most of the beds in and about the estuary of the Thames, it would be folly not to keep them constantly worked, as they would otherwise become useless in a very short time. On the other hand, where the grounds are so situated that they keep clean by the scour of the tide and the absence of deposits, the less interference they meet with the better. Lost fertility *may* be restored to an oyster bed by a close season being rigidly enforced, whilst constant dredging is not only desirable, but absolutely necessary where weed, mud and vermin accumulate rapidly.

It may seem hardly intelligible why, if at one period oyster beds were productive without artificial aid, they should require it afterwards ; but there are various reasons why this is so. When beds have been abandoned by dredgers, owing to their being able to obtain a greater number of oysters elsewhere, they may and do become ruined by the collection of mud and weeds that is formed; the soil having been once disturbed by dredging, becomes looser and more liable to shift, and thus weed, "slub," &c., drifts easily into the depressions caused by the abstracted oysters, or the drift of mud, organic matter, &c., attracts vermin in large numbers, just as a fisherman rakes the bottom to attract fish. In whatever way it may be accounted for, the facts that beds once worked have been ruined are certain—witness the examples of the Jersey and Granville beds.

All cultivated beds vary between the two following conditions: of being overcrowded with oysters, ware, and brood, &c.; and of having only a few parent oysters left on them.

In the former case, harrowing and dredging at any time of the year will do good in preventing the oysters from becoming overcrowded, for as there is only a certain proportion of oysters' food in any given quantity of water, redistribution over a larger area increases their food supply.

When, however, there are but few parent oysters left, dredging, especially during the spatting season, is most destructive. The iron rings and edges of the dredge must destroy some of the spawn and disturb the parent oysters to their disadvantage whilst they are breeding. Skin-back dredges are, we believe, seldom or never used on public grounds; whilst it is an almost if not quite universal custom for the fishermen to return the enemies to the water on such beds. It may be taken for granted that an oyster dredged up during its spatting season will not produce fertile spawn, and it is doubtful whether it will ever do so afterwards.

Although it is known that oysters produce an enormous quantity of young, it is very unsafe to count upon the actual number produced when considering the question of the future fertility of beds; calculations based on the actual number of spawn emitted by say a bushel of oysters, although represented by a long array of figures, are practically valueless; though it has been proved over and over again that the proportion which the number of young brood on a bed bears to the quantity of old oysters upon it is a pretty constant quantity. Mr. Pennell stated in his evidence before the Commission of 1876 that his experience at Herne Bay and Whitstable showed him that, apart from special cases where an eddy or current might tend to carry floating spat to one particular spot, the more old oysters that were left on the bed, the more young brood you would find.

Experience at Arcachon, Auray and Vannes, supports this: there the number of young oysters found on the collectors is always found to correspond to the quantity of old ones on the public reserves and in the neighbourhood.

Further, when the writer of this was dredging off Cancale last year, he found that on the beds which have lately become productive again, the proportion of young oysters (i.e. oysters under three years old) to old was as ten is to one, the result of two dredges-full being 251 young and 25 old.

The small bed of oysters discovered in 1870 in the Queen's Channel on the Whitstable Flats, which was destroyed in so short a time, afforded the same testimony to the rate of increase of oysters when left undisturbed.

The great success of the breeding establishments at Auray and Arcachon may be said to be due almost entirely to the determination of the authorities to keep up an abundant stock of oysters of all sizes, as shown by the limited time allowed for public fishing. During the last eight years only seven hours have been allowed in the Bay of Arcachon ; on the Cancale grounds public dredging is only allowed for six days during the year. Whether due to restricted dredging or not, there is no doubt that reproductiveness has been restored to these beds.

Private owners and companies very naturally object to any restrictions being placed on dredging on their own grounds or on public grounds. It is not at all likely that in their own interests they will allow over-dredging on their own grounds, whilst they would be only too pleased to be allowed to dredge as much as possible on the grounds of the public. An increase in the number of advocates against any restrictions being placed on the few public grounds that are left is the natural outcome of the policy of granting concessions of public grounds to companies, of which we will treat presently. If this course proceeds without let or hindrance, the goose that lays the golden egg will be slain, and oyster culturists will at last be rudely awakened to the folly of their policy, by finding that the remaining public breeding grounds are *barren.*

It is more than probable, however, that the cause of the failure of some private owners and companies has been a want of dredging rather than over-dredging. Bad spatting years and perhaps bad management have resulted in a want of the wherewithal, and thus their grounds have not been sufficiently worked.

2. *The Policy of granting Concessions of Public Grounds to Private Individuals or Companies.*

Before making any suggestions as to advantageous alterations or additions to the existing laws on oyster culture, we are led to inquire whether the policy of granting concessions of the foreshore or sea bottom to private owners and companies has been successful or not.

This system, inaugurated by the Herne Bay Company Act in 1864, and more fully carried out by the Sea Fisheries Act of 1868, has resulted in about thirty different orders being made by the Board of Trade and confirmed by Parliament. Further than this, the Herne Bay and Roach River Companies possess powers from special Acts of Parliament, though also subject to Board of Trade inspection.

The objects of these grants were no doubt the increased production of oysters, the stimulation of the industry of oyster farming, and the decrease in price of a most desirable kind of food. That these results have not been obtained is very evident, but whether the failure can be fairly attributed to the policy which dictated the grants is an open question.

We may fairly presume that another object the authorities had in view in granting concessions was the success of the concessionaires. Old-established corporations and private layings, though they have not perhaps done so well of late years as formerly, appear to have been fairly prosperous, but in those instances where companies have attempted by a large expenditure of capital to start flourishing concerns, the result has been a lamentable failure.

In 1864 nine square miles of the foreshore were granted to a company, and consequently taken away from public fishermen. Those who had charge of its affairs spent nearly half the capital before they earned a penny, and after having for some years maintained a precarious existence by selling off their stock, or in other words "living on their capital," they at length exhausted their resources. This was in 1877, but meanwhile the Board of Trade had in 1874, at the appeal of the fishermen of the neighbourhood, ordered an inquiry, which resulted in the nine square miles being reduced to a trifle over four. Another inquiry was held in 1881, when it was again found that the grounds were not properly cultivated, through the financial embarrassments of the company, and the four square miles were reduced to one. To sum up the results of this concession up to the end of 1881: it appears that for seventeen years a right has been taken away from public fishermen to fish on eight square miles of ground without any compensation being given to them, or any apparent advantage being derived by the public, whilst the experiment was attended by a dead loss to the concessionaires..

The absence of any but very small dividends to the shareholders of other companies who have received grants since 1868 gives us the impression that, generally speaking companies have not as yet been successful; whilst there is no doubt that sea fishermen who do not belong to any company, private owners and the companies themselves, are all at variance with each other. Independent fishermen loudly complain both of owners and companies, whilst private owners have a grievance against companies, and also against the actions of the fishermen on the common grounds that are left.

The rights of fishing in the territorial waters of the kingdom were confirmed to the sea fishermen of England by a provision of Magna Charta: these rights have been undoubtedly interfered with by the enclosure of certain waters. Whilst we are ready to grant that when the deprivations were sanctioned by the Legislature the promoters of the policy were able to hold out good prospects of advancing the general good, those prospects have not been fulfilled. We therefore think the time has come for a general investigation into the complaints of public fishermen against the concessionaires under the Sea Fisheries Act of 1868, with a view to a reversal of the policy that constitutes a direct infringement of the privileges conceded to our ancestors more than six centuries ago, without apparently any compensating advantage having accrued to the public.

As recently as September 1, 1879, Messrs. Buckland and Walpole recommended that inspectors should be empowered, with the authority of the Board of Trade, or the Secretary of State, to allot small portions of the foreshore or sea bottom to fishermen for oyster and mussel cultivation; to ascertain by inspection the result of such allotments, and to withdraw or continue them to the allottees as might seem desirable, reporting their decision in each case to Parliament. If this recommendation were widely carried into effect, the result would be that on those grounds where spat happens to fall, the grantees would be in a state of prosperity so long as the supply lasted; whilst where no spat falls, and brood unattainable, except at exorbitant prices, as is the case this year with "Natives," both proprietors and fishermen would be in financial straits, and the latter deprived of one of their principal sources of living. It is well known that spat sometimes falls at one place and then at another.

It is to the interest of oyster merchants, whether single individuals or corporate bodies, to keep up the price of their wares; capitalists can afford to do this by refusing to supply the market when there is any probability of its being glutted, whereas the poor fishermen have not the means of storing their oysters during a time of plentiful supply, or of living in the interim if they are stored. They are therefore obliged to sell what they have caught on public grounds to the companies at whatever price the latter choose to give, or else hawk them about the country offering them for sale at reduced prices ; though they well know oysters are kept quite long enough out of water when first brought on shore from the deep-sea beds, and great risk is run if they are transported elsewhere.

Further, the fishermen, who generally live a "hand-to-mouth" existence, can only afford to take a very small share in a company presumably got up to benefit them ; a bad year, sickness or improvidence, causes them to part with the small share they possessed, and the company drifts into the hands of one or two capitalists.

This is no supposititious case, as we feel convinced that in some of the companies now existing by far the greatest number of shares are in the hands of "long-shore moneyed men," who are quite indifferent to the fishermen's interest, and who manage the business as they like. The fishermen, instead of being partners, find they have exchanged their former freedom for hard task-masters and a "tale of bricks."

In defiance of the opinion of experts, who stated in 1877 "that the continued grants or concessions would result in the price of oysters being raised from £10 to £15 a bushel," concessions have continued to be made, and this year the price is £16 per bushel; thus their predictions have not only been realised, but exceeded.

If the price continues to increase at the same rate for the next twenty years, *Native oysters will be eighteenpence each*, and will be shortly after relegated to the same class of food as Chinese birds'-nests, which are sold for their weight in silver to make soup.

Another thing to be remembered is, that the higher the price the greater the inducement will be for excessive dredging on the public beds, hence the greater necessity there seems to be to introduce some measures for the preservation of these grounds.

No doubt the demand for oysters has largely increased in England of late years, but we question whether the great increase of price is wholly chargeable, either to the demand or to the failure of spat, and whether unwise legislation has not in a measure been the cause. At any rate, if the existing policy of granting concessions be continued, the logical deduction is that in the course of time there will be no public grounds inside the three-mile territorial limits, and outside of those limits we cannot enforce any laws except by international conventions.

It may be argued that the State or Board of Trade retains the power of withdrawing concessions in case the grounds are not properly cultivated, and that in at least one case this has been done; but in that case the company had powerful, if not jealous, neighbours to look after them. In other cases the weakest will go to the wall, and unless almost impracticable safeguards are instituted, the fishermen will continue to suffer, and the policy of granting concessions will not by any means do the greatest good to the greatest number. The preliminary expenses are *very* heavy, and a rent is charged for these concessions which, though moderate, is a good deal for the poor fishermen to pay; they are also granted without prejudice to any question of doubtful or disputed claim or right to the foreshores; these are facilities for the rich, and not for the poor.

Of the natural breeding grounds which yet remain public, those which are in proximity to private layings require the most active surveillance. The inspectors should see that no interference with the public right of free fishing takes place that will favour any particular owner or company, the percentage of oysters that die in transit varying directly as the time they are out of water.

If the Board of Trade continue to grant concessions, it will be necessary to considerably increase the number of inspectors to do justice to all parties. With the present inspectors we think it would be impossible to supervise the concessions already granted. Enquiries now only follow complaints frequently repeated; but none the less, when these complaints are well founded, injustice has been done, and surely legislation should have a higher aim than the *cure* of injustice.

We now see some of the same people who opposed concessions in 1877 applying for them in 1882 and 1883. "If some one must get it, why not we as well as others?" say they; "the Board of Trade will have their own way: we know that it is bad for oyster culture generally, but as the cake must be cut, we may as well share it; so '*sic transit gloria ostrea*.'" By these remarks we do not mean to suggest that owners of private freehold or copyhold oyster grounds should in any way be interfered with; they should be allowed to cultivate and manage their property in such a manner and at such times as they may judge best and most advisable for their own interests, dredging for buying, selling, and laying down oysters when and how it seems best to them.

Any interference with these holders would entail compensation for vested interests, and it should be borne in mind that local conditions and requirements are best understood by those accustomed to them, who have in many cases the accumulated experience of several generations to guide them.

In the early part of this year two applications were made for 3000 acres of the Blackwater to the eastward of the 2000 acres that were granted to the Mersea and Tollesbury Company some five years ago—one from Mr. John Smith, an applicant for various other concessions; the other from the dredgermen of Brightlingsea, Wivenhoe and East Donyland.

Mr. John Smith was non-suited. The evidence, as usual in such cases, was very conflicting. Dredgermen from other places deposed to the harm it would do them were these grounds closed; whilst the dredgermen of Brightlingsea, Wyvenhoe and East Donyland complained that the ground, formerly free to them, had been granted to the Mersea and Tollesbury Company, and that now in their turn they ought to get at least 2000 acres granted them for their exclusive use.

Evidence was also given that large quantities of the brood that was spatted in 1881 had been sold this year from the Blackwater and Pont, three millions having been purchased by the Whitstable Company. And if the 3000 acres were enclosed there would be but little of the Blackwater or Pont free to the public.

At the time we write we do not know what Mr. Holland, the inspector before whom the case was argued, has recommended or advised the Board of Trade to do.

With regard to future legislation, we would most strongly recommend that—

1. Dredging for oysters on natural or deep-sea beds should not be allowed between the 16th of June and the 16th of September, unless an inspector has certified that such dredging will not be harmful to *the future prosperity* of those particular beds.

2. The dredging for, consignment, or exportation for sale, or exposure for sale, for the purposes of consumption only, between the 15th of May and the 15th of September, should be made illegal, and punishable by fine, as between these two dates oysters are breeding.

It is necessary to note that unless the convention with France is modified or repealed, the permission referred to in the first suggestion cannot be granted outside the international territorial limits between the 16th of June and the 1st of September.

Were these suggested laws enforced in England, Wales, Scotland, and the Channel Islands, we believe that great advantages would ensue.

Ireland appears to have always been left alone in fishery matters, and not interfered with. Whether this is or is not "another injustice" to that country, we have no space or time to inquire, but it is a step towards what they desire so much—Local Government or Home Rule. The Irish Fishery Commissioners have far greater powers than those suggested to be conferred on the inspectors in our first recommendation, the Irish Commissioners having the power to close or open the beds at their discretion; whilst the English inspectors would only have the power of opening them if they considered they required working.

The effect of the second recommendation would be that all dredging for the market for consumption would cease for four months; but to allow of the breeding establishments being stocked, deep-sea oysters would be dredged for an extra month, i.e. from the middle of May to the middle of June, and thus artificial breeding encouraged. There is nothing in our suggestions that interferes with any international obligations, excepting that, as already stated, between the coasts of England and France dredging cannot take place between the 16th of June and the 1st of September.

If a natural bed was dredged during the summer months, the oysters taken therefrom would be used for breeding if the proposed laws were enforced.

There is a consensus of opinion that this large industry should be guided and protected. The value of oysters annually consumed in England is enormous, yet there is no inspector of oyster fisheries.

We hope to see the time when there is a permanent Fishery Commission, of which body the Inspector of Oyster Fisheries will be a member; the Inspectors of Salmon Fisheries, an Inspector of Trawling Fisheries, and two of Net Fisheries, would probably complete the Board. The interests of each class of fisheries, which so often clash with one another, would then be fairly represented, and some attempt be made to prevent the immense waste of fish that now takes place.

Lastly, in matters of fishery the coastguard should be utilised much more than is the case at present. They should be directed to refer to the Fishery Commissioners through the Board of Trade in the same manner as they now do concerning wrecks and life-saving apparatus.

If this was done, we submit that not only oyster—but all other fisheries would receive both protection and benefit.

OYSTER CULTURE.

"*The man who ends the day with an oyster in his mouth rises with a clean tongue in the morning, and a clear head as well.*"—BERTRAM. ('Harvest of the Sea,' p. 346.)

[DR. P. P. C. HOEK.]

OYSTER CULTURE.

OYSTER CULTURE is a branch of industry the object of which is to grow oysters. In many regards it may be compared to the breeding of cattle, the cultivation of plants, &c., but in one respect it is quite different. Hitherto no domestication of oysters has been successful: though they endure captivity very well, as a rule they do not propagate in that state. In consequence, what is called oyster culture consists in catching young oysters born of wild parents, and nursing and cultivating them till they are fit for the market. Therefore a complete knowledge of the animal in the wild state is indispensable, even more so than in other cultivating industries. Together with a short discussion of the anatomy and development of the oyster, its habits, occurrence, &c., will form the first part of the present essay, whereas its culture will be treated in the second part.

Before entering upon my subject, I wish to make the restriction, that the cultivation of the *Ostrea edulis* (L.), the so-called European oyster only, will be treated of. For comparison I shall speak of the American (*O. Virginiana*, List.) or Portuguese oyster (*O. angulata*) only in case it should be necessary.

I. The Oyster in the Wild State.

1. What kind of an animal is an oyster?

Zoologists call the oyster a Lamellibranch mollusc. Molluscs are those animals which have a symmetrical body, without an internal or external skeleton, furnished with a soft contractile envelope, which must be considered as a fold of the integument, and from the surface of which, as a rule, cuticular secretions, as hard calcareous plates, called shells, are produced; their nervous system unites in a certain number of ganglionic masses, dispersed in different points of the body; they have a well-developed system of circulation and distinct respiratory organs.

Lamellibranch or Acephale molluscs are those whose respiratory organs (*branchiæ*) consist of large lamellæ; they have no apparent head, and a mantle consisting of two large lobes, which inclose the body just as a book is inclosed between its covers. This mantle, as a rule, gives rise to a double (bivalve) shell. Lamellibranchiata form together a very characteristic class of animals, which in a very distinct, though perhaps not very natural, way is divided into two orders, viz. Monomyaria, with one muscular mass passing from one valve to the other, and Dimyaria, with two muscular masses.

Oysters belong to the Monomyaria; they have their mantle open, with neither tubes nor particular apertures. There are different species of oysters, which, however, in essential regards so much resemble one another that zoologists consider them as belonging altogether to one and the same genus, *Ostrea*. In the North of Europe, in the Atlantic Ocean, North Sea, &c., only one species of this nus occurs, i.e. the "common oyster," which has been named *Ostræa edulis* by Linnæus. Though there are numerous varieties—almost as many as there are places where it is found—the prevalent opinion of zoologists (Gwyn Jeffreys *) is that they all belong to the same species.

2. What is the geographical distribution of the oyster?

The geographical distribution of the oyster, which often, though not very correctly, is called the European oyster, has been traced by Mr. Winther.† According to him the oyster inhabits the coast of Spain as far south as Vigo, the French coasts from the south up to Finisterre, and the English Channel. It is found all round the coasts of Great Britain and Ireland, and goes as far north as the Shetland Islands. In the North Sea it is common along the shores of Holland and Germany as far east as Heligoland; along the western shores of Sleswick and Jutland; and, finally, along the western shores of Norway as far north as the island of Tränen, close to the Polar circle. The oyster is not found at the Far-oer nor at Iceland. At different points of this wide region the oyster is very common, at other places it is rather rare or totally wanting. By far the richest are the oyster-beds of the French and English coasts; only second to them are those of the Dutch and Sleswick shores.

3. On what bottom and at what depth does the oyster live?

Wherever oysters are found they always live in great numbers, crowded together. Such places are called oyster-beds. As a rule the bottom of an oyster-bed is neither rocky nor muddy, nor is it covered with sea-weed;

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* *Nature*, March 29, 1883.

† G. Winther. 'Om vore Haves Naturforhold med Hensyn til Konstig Oestersavl og om de i den henseende anstillede Forsög.' Kopenhagen, 1876. *Vide etiam:* 'On the Geographical Distribution of the Common Oyster.' *Ann. and Mag. of Nat. Hist.* (5), i. 1878.

it is always a mixture of sand and mud, or of sand, mud and shells. There is perhaps no circumstance so pernicious to the development of the oyster as a bottom of movable mud; yet this very mud is often rich in nutritive elements, therefore, when it is mixed with a sandy or shelly mass, it forms a bottom very favourable to the development of an oyster-bed.

As to the depth at which oyster-beds are found, it seems to be very difficult to give a general rule. Those of the coast of Sleswick-Holstein occur at a depth of 1 to 5 fathoms, those of the Borkum-riff at a depth of about 20 fathoms, those of the Scandinavian coast at a depth varying from 3 to 4 fathoms, &c. On the Dutch coast (Eastern Scheldt) oyster-beds are found at a depth of from 8 to 10 fathoms; the richest (the Yerseke oyster-bed) has a depth varying from 0·5 to 2 fathoms. A great part of the oyster-grounds of the basin of Arcachon falls dry with low water; they are traversed by channels, the most important of which have a depth of 6 to 7 fathoms, the smaller ones of only 2 to 4 fathoms. The Whitstable oyster-grounds have a depth of 1 to 1·5 fathom, those of Herne-Bay of about 1·5 fathom, &c.

These figures show that oyster-beds are found at greatly varying depths, the more common occurrence being that they do not lie so very deep; only when they are found at a greater distance from the coast their depth is more considerable. In this case the oyster-grounds are separated from the coast by a rather broad band, the depth of which diminishes towards the coast; and it is rather strange that the bottom of this band does not produce oysters.

4. Has the oyster a predilection for sea-water of a high percentage of salt?

As a rule oysters can very well endure transportation into brackish water; they propagate, however, only in sea-water which contains at least 3 per cent. of salt. In the open North Sea, where the oyster-beds occur at a depth of about 20 fathoms, the percentage is even 3·5. Perhaps the softer flesh of the oysters taken from beds near the coast is due to the smaller percentage of salt.

5. Does the temperature of the sea-water influence the existence or the propagation of the oyster?

In the North Sea the temperature of the sea-water varies between about −1° C. and + 20° C. Within these limits the life of the oyster is not endangered. As sea-water of 3 per cent. salt only begins to freeze at a temperature of −2·28° C., there is no danger whatever for an oyster as long as this temperature is not reached; and even when the temperature of the water has fallen so low, it becomes dangerous only for the oysters in shallow water. Where the depth of the water is more considerable, a layer of ice gathers at the surface, but near the bottom there will always remain a sufficient quantity of fluid water.* As the ice is formed of fresh water, the water at the bottom will necessarily arrive at a higher percentage of salt, which gradually makes the freezing more difficult still.

In another regard the temperature of the sea-water is of importance to oysters, as they seem to spat only at a high temperature of the water; in cold and wet summers (as, for example, those of 1881 and 1882) it was but for a few days that the water arrived at a temperature high enough for the development of the spat. On the Dutch coast it has been ascertained by experiment that an abundant spawning occurs only when for some consecutive days the temperature of the water does not remain much under 20° C.; such days were extremely scarce in both summers, and in both the quantity of spat fallen was below the average amount. That the oyster grows scarce under more northern latitudes is most probably not due to the temperature of the water being low during the winter, but to its not being sufficiently high during the summer.

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* C. Moebius. 'Auster und Austernwirthschaft,' 1877, p. 42.

6. Are there any other physical conditions that forward the thriving of the oyster on natural beds?

Of course there are, and probably such as we are quite ignorant of. Of those which are known, the influence of the tide is the most important. Where natural oyster-beds occur, the alternate rising and falling of the waters of the ocean, which we call the tide, causes a constant streaming, a constant refreshment of the water, so that it always contains a sufficient quantity of oxygenium.

Finally, it is evident that the oyster can exist only in water containing the necessary food. Oxygenium is the gaseous nourishment which the animal takes with the aid of its respiratory organs (gills or branchiæ), but it is also furnished with a well-developed intestinal tract, and requires liquid and solid food too. As the oyster in its natural (original) state is attached to the bottom, the only food it can get is that which is in suspension in the water and comes floating with the tide. The oyster is an omnivorous animal. With the muddy and sandy elements derived from the bottom, it introduces within its stomach microscopical plants (Diatomaceans and Desmidiaceans), and animals and a great deal of dead organic matter. Besides, very heterogeneous elements have been found in its stomach:[*] as pollen-grains, mites, small crustaceans, radiolarians, and often large quantities of spermatozoids and eggs of the oyster itself. As a rule the places inhabited by oysters may be said to be extremely rich in other animals too; they are perhaps the richest of the whole bottom of the ocean as far as animal life is concerned.

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[*] A. Certes, 'Note sur les Parasites et les Commensaux de l'Huître.' – *etin de la Soc. Zool. de France*, 1882, t. vii.

7. Anatomy of the oyster.

To understand the propagation of oysters it is necessary to have a notion—though not very minute, at least as correct as possible—of the anatomy of the oyster; so I shall first give a description of the animal as one whole, and afterwards mention the most remarkable data of the interior structure.

8. What does an accurate study of the oyster as one whole teach us?

The body of an oyster is laterally flattened, the surface on both sides coalesces with the mantle, which however round about projects over the edge of the body. The two halves of the mantle are entirely separated from each other, except just on the anterior side near the hinge, where its lobes are united; so they may be distinguished as right and left half of the mantle. Each of them secretes a shell, characterised by its irregular foliated structure; both shells show exactly the same size, but not the same shape; whereas the left shell, which is fixed to the bottom, is hollowed out and cup-shaped, the right-hand shell is almost entirely flat. To determine which is the *left* and which the *right* side of the body of an oyster, we may compare that narrow side, where the branchiæ have their greatest development, with the ventral side of our own body. As the mouth is placed on the narrow side, it is called the *oral*, the opposite side being designated as the *ab-oral* one. In the third place we may distinguish a *cardinal* and an *anti-cardinal* side. The cardinal side is where the two valves are joined in a movable way by means of a hinge, consisting of a little cavity on both sides and of an elastic ligament, which, when not stretched, causes the valves to stand open; this is always the case when an oyster carelessly enjoys the dainties which the tide affords. The ligament antagonises the action of the muscle, which runs a little beyond the middle of the shell from valve to valve, and serves not only to shut the valves, but to keep them shut too. So, whenever a danger approaches, the valves are shut almost instantaneously, and, when taken out of the water, they will remain in that condition for days. However, sooner or later, the muscle will become wearied out, and then it will not be able to counterbalance the elasticity of the ligament any longer; dead oysters always have their shells open.

In the natural state the cup forming the left-hand valve is attached to the bottom of the sea, to stones or other oysters; in what way this is done is not known; we know that it dates from the first hours after the falling down of the spat, and that it is generally considered to be caused by cementation.

With regard to organs of sense and of locomotion, the oyster has been very badly provided for. No doubt the border of the mantle, with its numerous tentacles, must be regarded as an organ of tact, but the senses of hearing, sight, and smell are probably wanting. Whether the sense of taste is well developed cannot be said with certainty; to a certain extent only has the oyster a predilection for distinct food.

As long as an oyster is attached to the bottom there can be no question of locomotion; the organ for that function, which the other Lamellibranchiata possess, viz., the foot, is absent in the oyster. According to different authors the oyster is capable of leaving the place it occupies—to a certain extent at least—by squirting out the water in consequence of a sudden closure of the valves.

The mouth is situated only a little behind the hinge, and is placed between two pairs of labial palpi; behind these, along one of the longer sides of the body, the respiratory organs, the gills or branchiæ, are observed. They consist of two pairs of large lamellæ and receive the venous blood, which from them returns to the heart.

Suppose we take away from an oyster the branchiæ and the lobes of the mantle which have the branchiæ between them; then that part of the oyster will be left which for the oyster-eater has the greatest attraction. We may call it the trunk of the oyster; it is that part of the body which includes the liver and the viscera. It continues into a stout process which at the oral side is pressed against the adductor muscle, and lies between this muscle and the branchial leaflets. When the branchiæ and the mantle are not taken away, the room in which this process is placed is laterally covered by the two layers of the cloak, and in this way a cavity is formed which may be called the *oral cloak-cavity*. On the other side (the ab-oral side) of the muscle, the soft part of the body continues into a very narrow process, which only contains the rectum. On this side, between the two layers of the cloak, another cloak-cavity (the *ab-oral cloak-cavity*) is formed, which however, and especially on the anterior side, is rather shallow. In the posterior part of this cavity the rectum terminates by means of the anus.

9. What is the interior structure of an oyster?

Of the interior parts of the body, the intestine, with the liver and the reproductive organs, is highly developed.

The intestinal tract consists of the œsophagus, the spacious stomach, and the intestine, which describes numerous convolutions, and a loop of which is continued in the oral process of the trunk. What is called the liver of the oyster consists of separate glandular masses communicating with the interior of the stomach and of the intestines by means of numerous separate ducts.

The nervous system of the oyster shows two large centra, viz., the cerebral ganglion, which is situated at the side of the mouth, and the mantle, or splanchnic ganglion, lying between the adductor muscle and the oral processus.

The organs of circulation consist of the heart and the blood-vessels. The heart is situated in a cavity which is found between the adductor muscle and that part of the body which includes the greatest portion of the liver and the viscera. The heart receives the blood which comes from the respiratory organs, and diffuses it through the body by means of vessels of a very simple structure; for the greater part their walls only consist of a somewhat stronger layer of the connective tissue, which fills up the interspaces between the different organs. The renal organs (Fig. 1) are placed on both sides in the surface of the body, and even in parts of the mantle. They have a very curious structure and are very highly developed; the different parts of the organ communicate with a vestibular cavity which is in connection with that in which the heart lies; on the other side this vestibulum opens in the same fold in which the genital organs open.

The genital or reproductive organs consist of the reproductive glands and the two ducts. There are neither accessory glands nor copulating organs. On both sides of the body the ducts open into a split at the surface of the oral process (Fig. 1. *u.s.*) close to and parallel with the

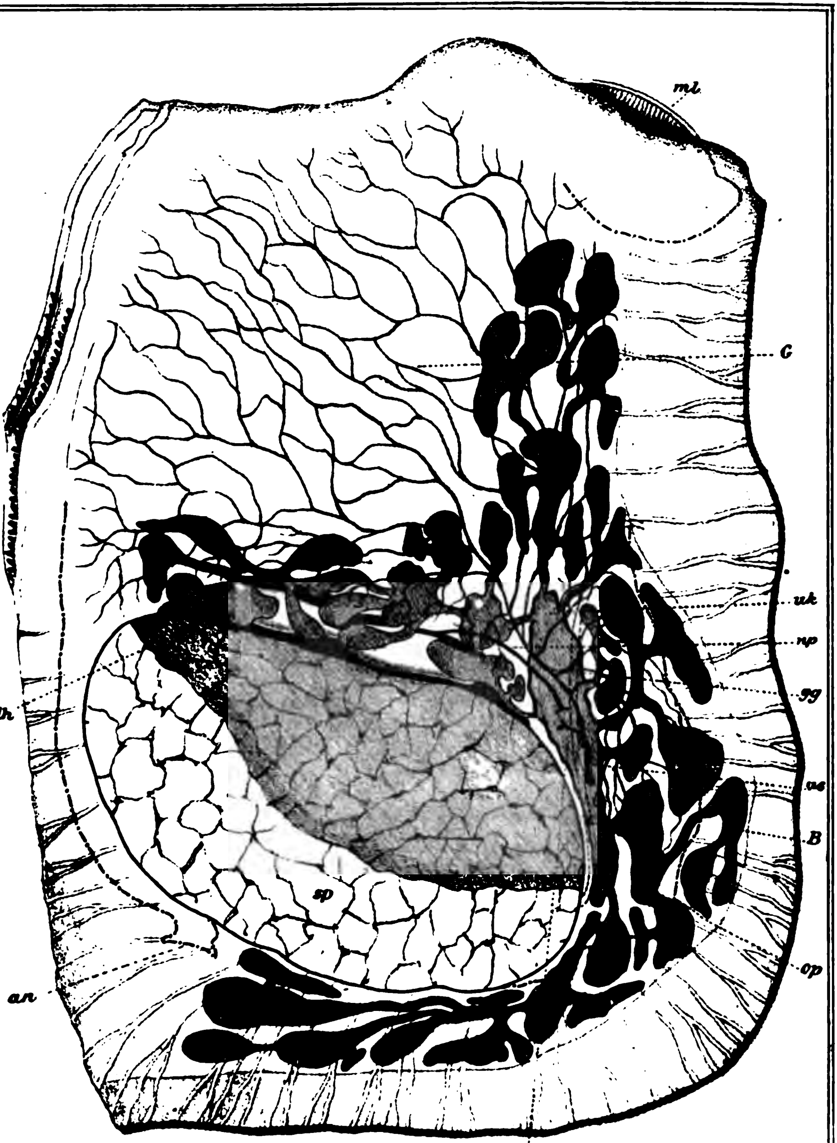

Fig. 1. Urogenital apparatus of the oyster. After Hoek. l.c.

G. Genital apparatus. g.g. main genital duct. B. Bojanus organ (Renal organs) uk. Vestibular cavity of the renal organs. np. connection between uk. and lh. lh. cavity in which the heart is found. us. fold in which the genital organs and the Bojanus organ open. sp. adductor muscle. ml. labial palpi. op oral process of the trunk. an. anus.

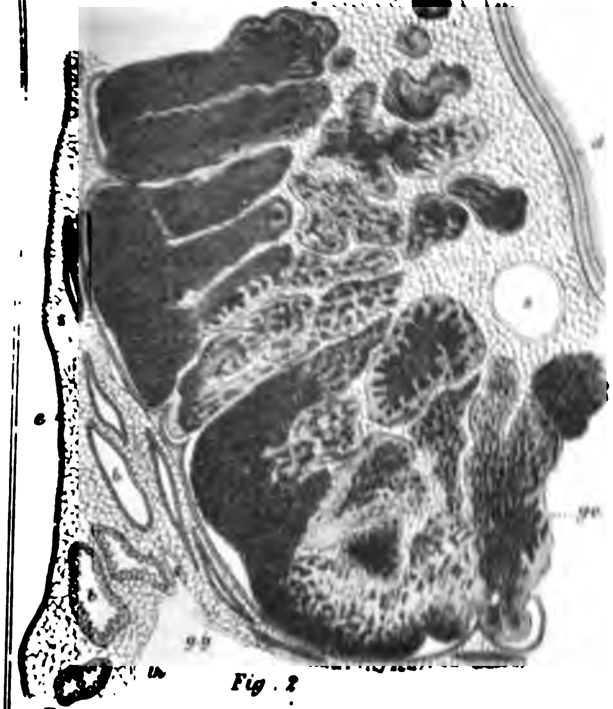

Fig. 2

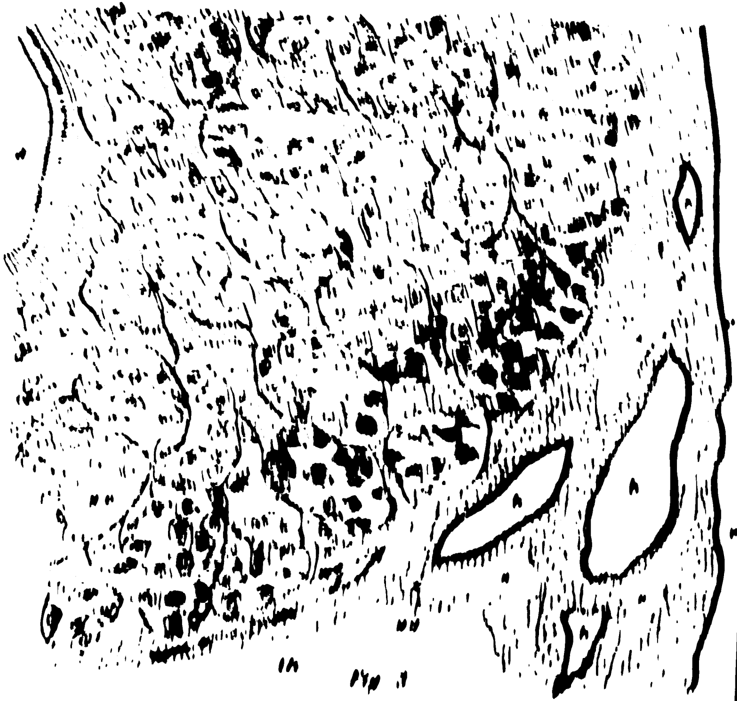

Fig. 1

Part of an oyster with well developed male genital products

Part of an oyster with well developed female products

The Two figures after Hoek l.c. In both, go = genital organs, gg = genital ducts, h = parts of the renal organs, lh = cavity in which the heart lies, a = bloodvessels, e = epidermis, d = intestinal tract border of the adductor muscle; hence it is clear that the products of the generative organs are poured out into the oral cloak-cavity.

The reproductive glands form a dense layer on both sides of the trunk (Figs. 2 and 3); the main duct has over its whole length lateral branches proceeding from it, which in their turn spread into branches anastomosing with one another, and so forming a network of ducts all over the sides of the trunk. This network of ducts is separated from the surface by a thin layer of connective tissue. That side of the wall of these ducts which is directed towards the interior of the body develops, perpendicularly to the surface, excrescences, the interior of which is in open communication with the duct. The genital products are found along the innermost side of the wall of these excrescences or follicles (Figs. 4–6); when ripe, they are evacuated by the duct, and pass over into the other ducts till they reach the main one, and finally the genital porus. The products of the two sexes, viz., the eggs and the spermatozoids, are developed in the same follicle, which for that reason must be considered to be *morphologically* hermaphrodite. As the same follicle, however, never develops both genital products *at the same time*, it is evident that the oyster does not fecundate its own eggs with its own spermatozoids, and therefore must be considered to be *physiologically* unisexual. And this, although there can be no doubt but that the eggs are fecundated, and even partly developed, before they are laid!

10. How and where are the eggs of the oyster fecundated?

As the question of the propagation of oysters is of great importance to their culture, a somewhat ampler discussion of the matter may find a place here. According to the latest [*] and most trustworthy investigations a young oyster may open its sexual career as well by producing eggs as spermatozoids. When eggs are developed—say in the second or third year of the oyster's life—they are evacuated all at a time; and as soon as the follicles are emptied the male products begin to develop at their walls. As far as our knowledge at present goes, a period in which spermatozoids are formed always succeeds the female condition of the follicles.

On the other hand, it is by no means the rule that the male condition is succeeded by a formation of ova. Probably an oyster does not evacuate all its spermatozoids at once, but continues to form new ones, while part of the contents of its glands and ducts is let out. So it may happen that an oyster continues for years to produce spermatozoids; and, for this reason, we need not wonder at it that a very great part of the oysters of a bed at one time produces spermatozoids, whereas the ova-producing part is much smaller.

Now this is a necessary condition, without which the propagation of the oyster would be an utter impossibility. As the spermatozoids which are let out, and which are united in globular spermatophores to accomplish the act of fecundation, ought to penetrate the genital porus of an oyster in female condition, and as the only way to reach it is to be passively brought thither by the wave, it is evident that for every spermatozoid reaching its destination millions—even myriads—must be let out.

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[*] C. Davaine, 'Recherches sur la Génération des Huîtres,' Paris, 1853. H. de Lacaze-Duthiers, 'Recherches sur les Organes génitaux des Acéphales Lamellibranches,' *Ann. Sc. Nat.* (4) ii. 1854. P. P. C. Hoek, 'Les Organes de la Génération de l'Huître,' *Tijdschr. Ned. Dierk. Vereen.*, —Suppl. Deel. i. 1883.

For the greater part these will get astray. Yet some of them will find their way into the genital porus of oysters containing eggs fit to be fecundated. They penetrate the main genital duct, and even the ducts which branch off from this and meet with the ripe ovarian ovà. Hitherto the fecundation itself has not been observed in the oyster, but no doubt it will show the same phenomena as in other animals.

11. What happens with the fecundated eggs?

The fecundated and partly developed eggs find their way to the branchial leaflets of the mother. When recently laid, they have a white colour, for which reason they are in this condition called "white spat." In warm summer weather two or three days only are required to convert this white spat into "black spat," in which condition the oyster embryo will be set free. Everybody who has studied the development of the oyster has made the observation that there are more mother oysters containing old (black) than young (white) brood; it seems to be the rule that the black spat continues for some days in the branchiæ of the mother. Perhaps this is not the case when the temperature of the water is sufficiently high; but it is possible also that the larvæ stay for a longer time within the mantle cavity, to have a greater size and more strength at the time they are set free. When the branchiæ of an oyster are filled with brood, the water which moistens their surface contains a notable quantity of albumen.

12. What is known of the life of the larvæ from the moment they are set free till they are observed to be attached?

Nearly nothing. To prevent the spat from being carried seawards on the ebb, it is thought that the oysters emit it as the tide is coming in. Whether this is true I would not undertake to say; nor is it possible to state anything with certainty about the length of the period intervening between the time when the larvæ are set free and the time at which they fix themselves. Perhaps the idea is a correct one that the larva only keeps on swimming till its weight causes it to sink, and that the increase of weight would be the consequence of the deposition of lime carbonate in the embryonic shell. One thing only is clear, viz., that the dangers to which the swimming larvæ are exposed are as numerous as they are various; therefore the percentage of the larvæ which, after having endured all these dangers, fall down in a place fit for their attachment, must necessarily be very small.

The accompanying figure (Fig. 7) shows a larva in the swimming condition.* Almost the whole of it is covered by the shell, the head or velar end of the body only being thrust out of it.

13. The spot where the oyster larva falls down must also be that of its attachment. So only those larvæ will grow up which fall down in a not too muddy or sandy, but hard and shelly bottom. In what way these larvæ attach themselves cannot be said with certainty. Their size immediately after their being attached—when they may be called young oysters—is rather small; young ones which were found attached measured only 0·57 mm. (about $\frac{1}{43}$ inch) in diameter, and it is very well possible that these had been attached already for some days. When once attached, the young oyster has only to grow to become an oyster fit for propagating the species. For those which fall down at a favourable spot (with regard to the condition of

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* R. Horst, 'On the Development of the European Oyster,' *Quart. Journ. of Micros. Science*, xxii. 341-347, 1882.

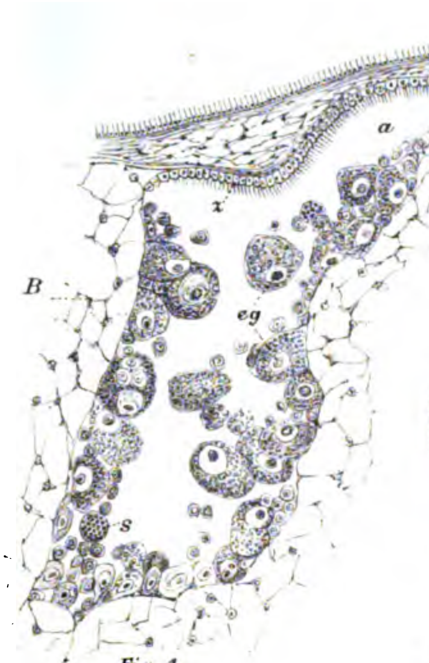

Fig. 4.

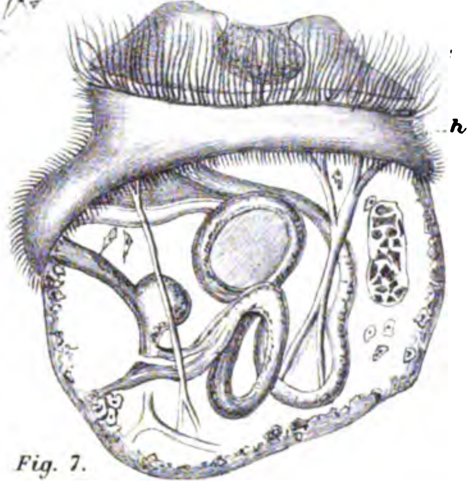

Fig. 7.

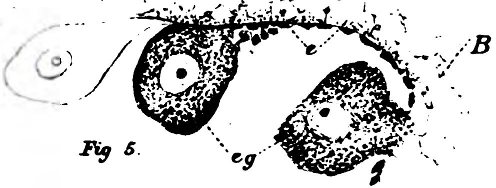

Fig 5.

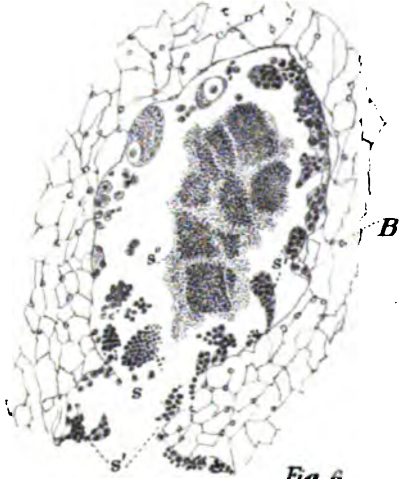

Fig. 6.

Fig 4. One of the excrescences of the genital apparatus in young female condition x epidermis. y connective tissue. z. epithelium of the wall of the duct. a. well developed excrescence. C. smaller excrescence. e.g. eggs. s. sperma in development.

Fig. 7. Oyster larva in the swimming condition after Horst.

Fig. 5 Nearly ripe eggs in one of the excrescences of the genital apparatus e. epitheliam

Fig. 6 Sperm in development after the eggs are laid off. s & s' sperm in development. s'' ripe sperm.

(In fig 4 - 6. B means the surrounding connective tissue. After Hoek. l. c.)

the soil, the depth, &c.), the chance of becoming a full-grown specimen has much increased, and has even become a good one, considering the time when it was still swimming at the surface.

14. What are the dangers to which the oysters, and especially the young ones, are exposed?

a. An insignificant change in the direction of the current may cause the heaping up of mud in a place almost clean when the young oyster attached itself there, and cause its death by suffocation. It is the opinion of the people employed on the oyster-banks of the East Scheldt that the presence of the common muscle (*Mytilus edulis*, L.) causes the mud to gather on oyster grounds where it had not been before.

b. An uncommonly severe winter may cause the death of the oyster by freezing. As shown before, this will be the case only with oysters in very shallow water. It is evident that young and feeble oysters will suffer more from this circumstance than older and stronger ones.

c. Want of food will not often cause the death of an oyster, especially because, as we have seen, it is by no means over-nice, and as the water running over an oyster-bed is always loaded with microscopic organisms and dead organic elements of food, whilst of course the sea water will also always contain the oxygenium necessary for respiration.

d. Oysters attached to one another, and also other animals attached to the shell of an oyster, may gradually hinder the opening of the shell to such a degree as to cause the death of the oyster. The animal which will do much harm in this respect is the *Alcyonium digitatum*, the sea-hand, which covers the shell of the oyster with its enormously thick and short branches.

e. The true parasites of the oyster are not very numerous.

The shell is often perforated by *Clione celata*, a boring sponge, which however, as a rule, does not endanger its existence. In the intestine of the oyster different species of small Protozoans are observed (*Hexamita inflata*, Dujardin, *Trypanosoma Balbianii*, Certes, both *Flagellata* [*]). Whether these ever become dangerous for the oyster is not known.

f. Most considerable is the loss which the oyster-beds may suffer from animals preying on the soft flesh of the oyster. In the northern part of the European oyster region, it is the common crab (*Carcinus mænas*, L.) and the star-fish (*Asteracanthion rubens*, Müll. and Troschel) which ravage the oyster-beds; on the French oyster-beds it is the *Murex erinaceus* (the "*perceur*" of the French), which is dreaded most. The first two suck an oyster (particularly a young one) which has been surprised when open; the *Murex* (and in the same way some other species of Gasteropodous molluscs) bore a hole through the shell of an oyster, and suck it by means of this hole. Other enemies are the rays. Whilst the shell is soft and tender, oysters have, of course, much to suffer from these enemies: especially dangerous they may be called for such oysters as have a broken shell or are suffering from bad health.

II. OYSTER CULTURE.

1. Historical sketch.

Even in pre-historical times, as is shown by the great accumulations of oyster shells in the "Kjökemoddings," the oyster was eagerly sought for. The first notice regarding oyster culture is, however, of a much later date. The

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[*] A. Certes, *loc. cit.*

Grecian historiographer Agatharsides (± 160 B.C.), speaks of a people dwelling or rambling along the coast of the Arabian Sea, and looking for shell-fish, which was very numerous there. Having brought great quantities together, those they did not want to eat immediately were put in pits, where they fattened them with sea-weed and with the heads of small fishes.

This information is of importance, I think, as it shows what has been the first and simplest form of oyster culture, but also as it states the occasion of its invention. The only thing wanting is the observation that the oyster will taste nicer after having remained in the pit for some time. But though, no doubt, the taste of the old Arabians was sufficiently developed for making this observation, it was left for the Roman people, in the gastronomic age of Italy, as it has been called by Bertram, to invent regular oyster culture.

The story of Sergius Orata and the oyster-breeding in Lake Lucrinus is well known. In its immediate neighbourhood is the Avernus of Virgil, which even now is devoted to the art of oyster-farming. It is called Lake Fusaro, and this lake for the history of oyster industry is important in two respects; in the first place, because here a regular culture was practised first (at least in Europe), and, in the second place, because the Lake Fusaro system of cultivation has been the model from which (about 1859) the culture as now practised on the French and Dutch coasts has been introduced. Whether Sergius Orata used the waters of Lake Lucrine for fattening purposes only, or also for breeding new generations of oysters, is not known, nor does it matter much. When M. Coste visited Lake Fusaro about 1858, the plan of the oyster breeders there struck him as " being eminently practical, and suitable for imitation on the coasts of France." This "mode of oyster-breeding was to erect artificial pyramids of stones in the water, surrounded by stakes of wood, in order to intercept the spawn, the oyster being laid down on the stones." * Faggots of branches were also used to collect the spawn, which, falling down some time after its emission, requires a holding-on place, or will be lost for ever. To understand the success of the oyster-culture practised in Lake Fusaro it is necessary to know that the lake communicates with the sea by means of a canal, and that, in order to prevent the swimming out of the larvæ, screens are placed before the opening of this canal.

As I mentioned before, the French oyster culture is based on the same principle as that of Lake Fusaro; at the instigation of M. Coste this system of cultivation was strongly recommended by the French Government to the French people. However, it is well known that at the same time Coste meditated his plans, oyster culture was already successfully and independently started on the French coast, namely on the Ile de Ré, by the stonemason Lebœuf.

The first attempts in other places, the well-known St. Brieux experiments, were also very successful in the beginning; moreover the French Government did its utmost to support the new industry, as well by instituting imperial *parcs*, as by granting portions of the shores to be cultivated as oyster-parks. Accordingly at different and numerous parts of the coast the new industry was vigorously prosecuted; about twenty-five years have elapsed since that time, and, much better than in the first years after its introduction, we are now capable to judge of the success of the culture. And, as this French culture must be considered to be of a high development I will try to give a short account of its most interesting points.

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* James C. Bertram, 'Harvest of the Sea,' 1865, p. 350.

2. The French oyster industry.[*]

The oyster culture, as suggested by M. Coste, is only one of the branches of the industry which has to deal with this shell-fish. If we call oyster culture the collecting of spat, the rearing of the young oyster is already a separate branch; the oyster industry, moreover, embraces the fishing on the natural beds, then the fattening, finally the greening of the oyster; the fishing—by dredging, by hand-picking, and with small rakes—is no doubt the oldest branch of oyster industry. The points at the French coast where at present it is practised with success are Granville, Cancale, Auray, Vannes, and Arcachon. Long ago the production of the public oyster-beds in these places was very satisfactory, but then the prices of the oysters were very low; the demand for oysters was nothing to what it has grown to since the invention of steamships and railways. As these enabled even the inhabitants of Central Russia to feast on this dainty, a much greater demand for oysters was the consequence, and almost everywhere the oyster-beds began to be more or less exhausted by too much fishing. At different places over-fishing has totally ruined oyster-beds known to have been very rich not very many years ago. At the places named above, the Government has in time prevented this by restricting oyster fisheries year by year, so that at present, on the richest oyster-grounds of Auray and Arcachon, fishing is allowed only about one hour of one day all the year!

Those public oyster grounds of the Bay of Arcachon are partly situated on flat beds, where fishing by hand and with small rakes is possible, partly in the channels, where the oysters must be taken by means of the dredge. By instituting a special service of guards, the Government secures the observation of the rules prescribed, and a splendid success in many places has crowned its efforts. The public beds as well in Auray as Arcachon are so thoroughly stocked with oysters that, notwithstanding the very short time during which dredging or hand-picking is allowed, millions of oysters may be collected. In order to enable the administration to fix the time (in Arcachon, *e.g.*) for fishing to be allowed, the fisheries are annually inspected with great care, some time before the usual fishing season. When the number of oysters is not judged satisfactory, no fishing at all is permitted ; and in the Auray district there are, moreover, two permanent state preserves for replenishing with oysters such public beds as might show a scarcity of stock upon any part.

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[*] Major Hayes, 'Report on the Principal Oyster Fisheries of France,' 1878.

The oyster culture *par excellence* as practised with great success in Auray and Arcachon, and, though hitherto with much less profit, also in Vannes and Cancale, is a true foreshore culture. Its success depends on the quantity of spat emitted by the oysters on the public beds, and this quantity, of course, is dependent on the number of full-grown oysters on the beds. For the spat not only serves to keep up the stock to meet the requirements of the fishermen, but a great deal is scattered over the grounds given in concession to the oyster-cultivators. Whereas the public oyster-beds generally occupy the main channels, the concessions are found immediately adjoining to these, and extend from them to the shore. The way in which the spat is secured is very simple, and consists in placing *collectors*, which serve the falling spat as a holding-on place.

Very different objects—shells, stones, tiles, cockle-shells, clung closely together upon wire (*Chapellets*, as they are called by the French), beads of clay clung together on strings, &c., are used as collectors. As the cultivator aims at furnishing a clear surface to the falling spat, the collectors are placed in the water only just before the spat is in it; when the first falling of spat gets lost by intervening cold weather, and the collectors are consequently to remain for a long time in the water before the new spat falls down, it has proved successful on the Dutch coast to remove them and replace them after having cleaned their surface. On the smaller materials (cockle-shells, beads of clay, &c.) the young oysters may remain, but on the tiles a longer stay would give the oysters too flat a form to be marketable. To prevent this the young oyster is carefully taken off some months after its having attached itself on the collector.

At Arcachon the collectors are placed on the margin of the banks and near the channels, but always on the concessions. In the same way a very considerable number of concessions of foreshore culture have been made by the Government near Cancale. Here they are situated close to low-water mark, also with the object of catching the spat coming from the natural beds. Near Vannes, in the Gulf of Morbihan, the beds where collectors are placed border also on the public beds.

On the French coast another method of culture is practised which perhaps resembles more still the Lake Fusaro system of cultivation. This method consists in catching on collectors placed within an enclosure the spat of oysters laid down within the same enclosure. In the method more commonly practised, the oyster-cultivators, as we have seen, lay down the spat collectors on conceded oyster-parks placed as near as possible to the public oyster-beds.

These are kept well stocked by the care of Government, and here the oyster lives quite in its natural state, and produces a very strong and abundant progeny. To get the lion's share of this progeny is what foreshore culture aims at. But the oyster-cultivator has to pay for his concessions ; moreover, the costs of laying down the collectors on the concessions adjoining the public beds is very considerable. The removal of the collector from the concessions to the places where the spat is loosened from it requires new expenses. All these charges are avoided by the methods practised with success by M. d'Argy at Brénéguy-en-Locmariaquer. He laid down (Report, Major Hayes, 1878, p. 11) six millions of oysters within a vast basin containing 900,000 cubic mètres of water, protected by dykes and furnished with sluices. The water in this basin is not changed above twice a month, whilst in the intervals the winds keep up a sufficient alteration of the water, and prevent its becoming "stagnant." * The oysters were laid down in 1876, and the efforts of M. d'Argy seem—in the beginning at least—to have been crowned with complete success, for in October 1877 the quantity of spat attached to the collectors in the basin was estimated at forty millions !

To distinguish it from the foreshore-culture I propose to call this system of cultivation basin-culture. As far as my knowledge goes, the case of M. d'Argy is the only one of this system having been practised with success. The oyster-cultivators of the Ile d'Oléron place in their *viviers* numerous oysters of all sizes, as well as collectors. Whether the spat which afterwards is found attached to these collectors is produced by the imported oysters or by those from the natural banks cannot be said with certainty. But, as the *viviers* are placed far down on the sands, near the margin of the current, I do not think it safe to consider Oléron culture as basin-culture.

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* Bouchon-Brandely, *vide* Report, 'Oyster Fisheries of France,' of Major Hayes.

The other branches of the French oyster industry are, as we have seen, the growing, fattening, and greening of oysters. Some details about them may find a place here. In the Auray district the collectors are left alone, with the young oysters upon them, until the month of March or April; whereas in Arcachon the collectors are brought in the month of October to the different establishments of the proprietors on the beach, where women are employed to remove the young oysters. These are put in boxes called ambulances, the top and bottom of which are composed of wire or perforated zinc, with meshes or perforations—so small as to protect the young oysters from the depredations of their numerous enemies, but still sufficiently large to freely admit the water in which they are placed. Whilst at Arcachon the young oysters are kept only a short time in these ambulances (one month or so), they remain for several months in them at Auray. The ambulances are placed either in parks where the depth is considerable, or as near to low-water mark as possible, or in or near a current. This last way has been thought preferable because the growth of young oysters proceeds with greater rapidity when there is much motion in the water. As soon as they have attained a sufficient size and strength, they may be sown on the concessions, in the oyster parks, *claires*, &c. They want fattening to become oysters fit for the market. It is not surprising at all that many places extremely fit for collecting spat are not so for the fattening of the oyster. In some of the places which supply the market with oysters possessing a high reputation, fresh water is always mixed with the salt water supplying the parcs (Courseulles-sur-Mer, &c.). Whereas the taste of the oyster is improved by this method, its procreating power is greatly diminished by it. This is also the case with the greened oysters of Marennes and La Tremblade.

As to the cause of this green colour many interpretations are given. M. Puységur * ascribes it to the presence in the water of a green diatom, *Navicula ostrearia.* In American green oysters these diatoms have not been observed; Mr. J. A. Ryder † gives as the cause of the green colour a tincture of the blood-cells either derived from green vegetable food, or possibly the effect of certain food upon the secretions of the liver, which have changed their colour.

However, from a general point of view, the question whether basin-culture can be practised with success is, I believe, a more interesting one than that of the greening, perhaps even than that of the fattening, of oysters. It is at present the question which occupies oyster-culturists most; but before entering into particulars about it, I will give some details on Dutch, German, and English culture.

3. The Dutch oyster culture is that of the East Scheldt. The whole oyster territory is given in concession. Whereas part of the concession is used for fattening purposes, another part is reserved for laying collectors, whilst there are also places where a natural development of oysters takes place. These belong also to the concessions; so we have a very remarkable difference between the French (the Arcachon and Auray) culture, and the East Scheldt culture; viz., in the former we find *public* oyster beds in addition to the concessions, in the latter, not. Therefore, on the Scheldt it is not the Government that looks to a sufficient

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* *Nature*, xx. 1880, p. 549.

† *Forest and Stream*, Nov. 30, 1882.

stock of full-grown oysters producing spat (as in France), but the concessionists themselves are obliged, in their own interest, to provide for a good quantity of reproductive oysters. As the concessions of different oyster-culturists are situated close to one another, and as the current of the water prevents the spat from staying in the place where it was emitted, the oyster-culturists depend much on one another; there are parts of a very high value for the quantity of spat falling down there, though not a single full-grown oyster is to be observed.

Probably, however, the above-named difference between French and Dutch oyster culture is a totally chimerical one; though there are no public oyster-grounds, and protection of Government is not intended, the State unconsciously provides for the concessionists. The shores of the Scheldt are protected by high and strong dykes, and for the protection of the latter enormous quantities of stones (basalt, &c.) are precipitated at their feet. It is of course impossible to dredge on these rock-masses; besides, with a view to the preservation of the dyke, it is not permitted to let down a dredge within 500 mètres from its base. Recent investigations made with the aïd of a diver * have brought to light that, almost everywhere along the Scheldt oyster territory, the stone masses are covered with very rich natural oyster-beds! So it is supposed that a considerable part, at least, of the falling spat is not produced by the oysters laid down on the concessions, but by these natural banks along the dykes. Thus we see that Dutch oyster culture probably differs in no essential regard from French culture, and must be regarded as a true foreshore culture.

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* 'Rapport sur les Recherches concernant l' Huître et l' Ostréiculture,' liv. i. Leide, 1883.

For protecting young oysters during the winter, and also for temporarily preserving marketable oysters, Dutch oyster-culturists construct large pits within the dykes, or immediately adjoining to the dykes. The dyke which protects the pit at the side of the sea is furnished with sluices; the walls and the bottom of the pits are made of wood and masonry. Different oyster-culturists have tried to collect spat on collectors placed within these pits, but all their efforts in this direction have been in vain.

4. German oyster industry.

At the German coast (in the neighbourhood of Norderney, &c.) and at the Sleswick coast it has been repeatedly tried to introduce French oyster-culture, but without any success. Moebius, a well-known authority for all that regards the oyster and oyster culture, believes that it is the low temperature of the water in winter, and the violence of the waves during high spring-tides, increased by tempests, which oppose themselves to oyster culture after the French method. According to him, at the south-eastern shores of the North Sea, the lowest tides always occur when the coldest winds are blowing; and, as we have seen on p. 383, a low temperature of the water is much more dangerous for oysters placed in shallow than for those found in deep water. Moebius therefore thinks that the oyster production of the German waters cannot be augmented by culture; but that this can be effected in the first place by keeping a sufficient stock of full-grown oysters on the existing oyster-beds, and in the second place by ameliorating and enlarging the places fit for the fixing of the oyster-spat.

In the Baltic the percentage of salt is too low for the oyster to live in. Of course there can be no question of oyster culture there.

5. Oyster-culture in England.

England wants yearly an immense quantity of oysters. They are partly supplied by America, partly by France, partly by the Dutch oyster culture. By far the greater part however is produced by the English oyster industry. We do not say English oyster culture, for, if taken in the real sense of the word, we must confess that it does not exist on the English coast. Yet there is perhaps no other country where such costly measures have been taken to introduce a true cultivation of oysters as in England. The aim of these measures was to obtain basin-culture; those of the South of England Oyster Company at Hayling Island are well-known, and it is also known that here as well as in Herne Bay, and near Reculvers, in the estuary of the Thames, they proved a complete failure; the price of an oyster, as stated (1876) by Mr. Blake,* Inspector of Fisheries, when obtained by this culture, amounted to £50 to £100, and even to £500! Whether these efforts have been given up, or are continued still, I have not been able to ascertain. I suppose the former must have been the case; if they are continued still, we should—though perhaps with an immense loss of money—possess much better information about that special kind of oyster culture which we have called basin-culture than is the case now.

6. Is basin-culture possible or not; and, if so, can it be practised from an economical point of view?

This is at present, I believe, the most important question in regard to oyster culture. For its discussion, the trustworthy scientific material we possess is rather trifling; on the success of M. d'Argy in the Brénéguy-Locmariaquer establishment our information goes no further than when the spat has attached itself; but we do not know whether the 40,000,000 spat individuals have produced a sufficient quantity of marketable oysters. In the establishment at Hayling Island the quantity of spat collected in the first summer was estimated at 120,000,000; yet, as I have said above, the culture proved a failure, for the quantity of marketable oysters reared from this immense quantity of spat was of no consequence whatever.

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* 'Report from the Select Committee on Oyster Fisheries, &c.' July, 1876.

To produce a healthy and resistive progeniture an oyster must be itself as vigorous and healthy as possible. If an oyster be grown up in an enclosure, let it be large and in communication with the ocean in the usual way, it is evidently very difficult, if not impossible, that this oyster should be of the same strength and health as those which are placed in the open ocean. The two reasons which must necessarily bring about this difference are: in the first place, that the aeration of the water (its oxygenium-quantity) is not sufficient, and in the second place, that there cannot be abundance of food within an enclosure. No doubt, the changing of the water can to a certain extent make up for this disadvantage; but there is sure to remain a very notable difference in strength between the oysters grown up within such an oyster-tank and those found in the open ocean.

And this difference will in the first place affect their reproductive power; a smaller percentage of those oysters will come to maturity, this will take place at a later age, the quantity of spat produced by one of them will perhaps be less considerable, and finally, what is to be feared most, the spat itself will not be healthy. To prove the correctness of this statement I need only refer to what has been shown by observations on the Dutch concessions of the East Scheldt. The oysters distributed over the different concessions are by no means in such unfavourable circumstances as those placed in enclosures; yet for a great part they do not grow up in the natural way; nor do in many places the bottom they inhabit and the depth at which they are found quite correspond to that of the natural oyster-beds. And what is the consequence of this? That everybody who bestows his special attention on the matter is struck by the small percentage of mature oysters. The great bulk of the spat which attaches itself to the collectors on the East Scheldt concessions is not produced by the cultivated oysters, but by the natural beds. These belong partly to the concessions: they are the places where, long before oyster culture was introduced on the East Scheldt, oysters were dredged; partly these beds are found on the rock-masses at the foot of the dykes.

Whilst it is not possible, I think, to bring the oysters within a tank or basin under conditions similar to those of the natural oyster-beds, there seems to be another way to avoid this inconvenience. We have only to wait till the oysters of the natural beds are mature, to collect a sufficient quantity of them, and to bring them in the basin where the collectors are placed. This method, however, seems to be more effective than it is in reality. Oysters taken from the deep do not endure transplantation in shallow water, and soon die; but, even when taken from water of about the same depth as that in the enclosed basin, they will not propagate at all, or only after having been in the basin for some months. Nor has the experiment to transplant an oyster containing brood within its gills ever led to a noticeable result; and I think it hardly recommendable to continue experiments in this direction.

In case basin-culture in general should be tried again, the enclosures should afford all possible means to renew the water. A constant aëration of the water is not only to be kept up, but also an abundant supply of food is to be acquired. Moreover, the bottom of the basin must resemble, as much as possible, that of the natural oyster-beds; and this will not be an easy matter, for an abundant supply of food will necessarily bring with it plenty of mud, which within the enclosures will not be carried away again with the current, as is the case on natural oyster-grounds. Now it is evident that, whereas a small quantity of mud is by no means disadvantageous to an oyster, and even may be of great advantage where the fattening of the oyster is aimed at, yet a too large quantity of mud will even endanger its life. To prevent this by arranging a fore-basin for the water to clarify before the one in which the oysters are put, is of no use; for in that case the oyster will also lose a great amount of the food-particles contained in the water and among the mud-particles.

Another danger arises from the renewing of the water in the basin, viz., that it is not to be got without free circulation, which enables the spat, when in the water, to escape from the basin. I think it impossible to prevent this by filtering apparatus placed before the sluices. The only way would therefore be to control every day in summer the condition of the oysters, and to prevent any circulation and renewing of the water in the basin during a short time (one or two days), when there is a considerable quantity of spat in the water. As soon as it has fallen down and the attachment has been achieved, the sluices should be opened again to allow renewing of the water. How to protect the young spat against the danger of suffocation in a basin where a considerable quantity of mud must gradually fall down, is a last difficulty for which there will hardly be found a remedy.

Therefore, though I shall not deny the possibility of basin-culture being successfully practised under certain very favourable circumstances, I wish to give as my conviction that the future of oyster culture lies in foreshore-culture. It may no doubt be practised in many places where at present it is not. The only thing which, in my opinion, is absolutely necessary for its success, is the presence of a natural oyster-bed in the neighbourhood; and, as this oyster-bed must supply the spat which the culturist wants, it must be kept stocked as full as possible. It is, I think, evident that, after all, foreshore-culture is nothing but a method of enlarging existing oyster-beds. But as the oyster bed will, of course, be found on a bottom fit for it, it does not matter very much, I think, whether the bottom on which the collectors are placed is muddy, sandy or rocky. To keep the natural oyster-bed in a good condition, dredging must not be neglected, for this is—as is well known—the best way to clean the oyster ground. However, the quantity of oysters to be taken away must not depend on the avidity of man, but on the greater or smaller surplus of the stock. To determine this a careful inspection should be made every year, before dredging is permitted.

7. Is it possible to create new oyster-beds?

To enlarge and improve existing oyster-beds must be strongly recommended; does not their existence in a place prove its peculiar fitness for them? To create new ones may be tried too, but the success of attempts in this direction is extremely uncertain; the quantity of spat spread in the water every year is such an immense one that one feels inclined to admit that, almost at every place where such efforts could be made, Nature must have had the start of man.

Whether such efforts must be made by the Government or may be fairly left to the energy of the public I shall not discuss. To the French industry the interference of the Government has proved very salutary, but I think that it is still more creditable to the *bons sens* of a nation when such interference may be esteemed unnecessary.

8. Can the eggs of the oyster be artificially impregnated?

Of late there has been question of artificially impregnating the eggs of the oyster. This has been done with success—at least in so far that free-swimming larvæ have been obtained—with the American,[*] and with the Portuguese oyster,[†] which perhaps is the same as the American one,[‡] and at any rate a near relation of it. But, whereas in other respects the American oyster seems well adapted to follow the European species, the eggs of the American one are different in so far that they do not undergo development in the mantle cavity of the mother, but in the open ocean.

At the Edinburgh Fisheries Exhibition spat of *Ostrea edulis* five months old was exhibited which was said to have developed from artificially impregnated eggs. I need scarcely say that I do not attach any importance to this communication. For, in the first place, there can be no doubt but that the eggs of *Ostrea edulis* are already fecundated at the moment they are laid off; and, in the second place, these eggs ought to develop within the gills of the mother, as is shown by the presence of albumen in the water between the branchial leaflets, when they contain eggs or spat.

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[*] W. R. Brooks, 'Development of the American Oyster.' Studies Biolog. Lab. John Hopkins, Univers, iv. 1880.

[†] Bouchon Brandely, 'Comptes Rendus de l'Acad. des Sc.,' 31 Julliet, 1882.

[‡] Gwyn Jeffreys, *Nature*, 29 March, 1883.

9. Concluding remarks.

I tried in this treatise to develop my ideas as to the present condition and the future of oyster culture. I tried to give them as solid a basis as possible, not by comparing oyster industry with fish culture—an industry with which it has in my opinion scarcely any features in common—but by penetrating, as Moebius did for the German oyster industry, as far as possible into the mysteries of the conditions which favour or hinder the life and the propagation of our interesting shell-fish. I got my information as well from my own observation as from that of others published in numerous papers.* Where this information is insufficient—as I regret to say has often been the case—the conclusions must necessarily be lacking in precision.

I did not give any details as to the best methods for laying out parks, for constructing basins or inclosures, for composing collectors, ambulances, &c. They have been described in numerous papers, and general rules for their construction are not to be given, as they must greatly vary according to the circumstances under which the culture takes place, and also according to the materials for their easiest and cheapest construction. In my opinion it does not matter much what kind of collector is used, whether the tanks are enclosed by wood or by masonry, whether the ambulances are somewhat smaller or larger. The success of the industry only to a certain extent depends on these details, but much more on the temperature and the oxygenium of the water, on the direction of the currents, on the supply of food, on the habits of the spat.

Finally, I wish to point out that, what the meadow and the open air are for cattle breeding, the open water and the

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* 'Revue bibliographique sur l'Huître et sur l'Ostréiculture.' '*Tydschr. Ned. Dierk. Ver.*' Suppl. Deel i. 1883, p. 1–112.

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THE BEST MEANS OF INCREASING THE SUPPLY OF MUSSELS AND OTHER MOLLUSCS (OYSTERS EXCEPTED) USED EITHER FOR BAIT OR FOOD.

To any one who is acquainted with the hook-and-line fishing as an industry, this subject must commend itself as one of the first importance, while its bearing directly on the future food supplies of the nation will be regarded with no inconsiderable interest.

Owing to the unsatisfactory nature of the fishery statistics which we possess, it is only possible to form an approximate estimate of the quantity of mussels required for bait every season. It is a well-known fact that the supply of mussels is not equal to the demand, and indeed these molluscs are now getting so scarce that in some districts they are only to be had at famine prices.

On the north-east coast of Britain, from Flamborough Head northward, and on the north and west coasts of Scotland, mussels are the principal bait in use, and they are more or less in demand at various fishing stations on the west and south coasts of England.

The fishermen of Eyemouth used 890 tons of mussels for bait for the season 1881–2, being at the rate of 4⅔ tons per man. Although this would be much too high an average to take per fisherman in other places where mussels are the bait in use, it is within the mark to state that 100,000 tons are required every season for the long-line fishing.

Some idea of the disadvantages under which fishermen labour from the scarcity of mussels bait may be formed from a statement made by the Sea Fisheries Commissioners in their report, 1879, page xxxi. Under the heading of "Cockles and Mussels," they there state:—

"Unfortunately there can be no doubt that mussels are annually decreasing in abundance. Complaints were made to us of a decrease of mussels at all the principal line-fishing stations of Eastern England, and we are almost inclined to conclude that the line fishing is suffering as much from the scarcity and decrease of mussels as it is from the operations of the trawlers."

The use of shell-fish as bait is principally confined to the mussel, whelk, limpet, and clam.

The mussel (*Mytilus edulis*) is abundant everywhere, from high water-mark to the depth of a few fathoms on a rocky, stony or muddy bottom.

There are four varieties. Var. 1, *ungulata;* Cornwall and Channel Islands at low spring tides. It attains considerable size. Specimens have been obtained nearly five inches in length. Var. 2, *incurvata;* on all rocky coasts, filling crevices, and crowded together so as to prevent the free development of each individual. Var. 3, *galloprovincialis;* solitary, and therefore more expanding. Var. 4, *pellucida;* on floating buoys and sunken wrecks, often at a considerable distance from the land.

The mussel has the power of attaching itself to rocks and stones by means of its "byssus," a sort of silky hair which the animal secretes for this purpose. It is occasionally found with the periwinkle, living on the shore in a stream of perfectly fresh water during the recess of the tide. Although used to a certain extent as food, its chief value is as a bait for the long-line fishing. It is gathered from beds or scalps when the tide is out, or taken from the bottom of the sea or estuaries by means of a sort of grapnel dredge.

The whelk (*Buccinum undatum*), known in Scotland as the buckie, abounds on every kind of ground in all parts of the British seas, from the shore to the greatest known depths. They are in great demand as a bait for the cod smacks, and, owing to their toughness and the good hold they consequently give to the hook, are particularly well adapted for this purpose. The procuring of this bait is a regular trade, in which many small craft from twelve to fifteen tons are constantly employed. Each smack takes about forty wash* for the voyage, which are kept alive in netted bags in the vessel's well till required, when the shells are broken and the animals extracted. Whelks are obtained in three different ways. The method adopted about Harwich is that known as "trotting," in which shore crabs are threaded on the snoods of a piece of long line. The whelks fasten on to the crabs when devouring them, and are drawn up with the line. Another mode is by means of pots constructed on the principle of crab-pots, with bait inserted inside to attract the whelk.

The third plan is to use a weighted hoop-net with bait, on which the whelks collect, and are easily drawn to the surface.

Evidence was given before a Select Committee of the House of Commons in the session 1866, that the whelk fishery on the sandy flat in Whitstable Bay yielded £12,000 a year. Part of the whelks were disposed of in London for food, and part supplied to the cod smacks.

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* A wash is a stamped measure capable of holding twenty-one quarts and one pint of water.

The limpet (*Patella vulgata*) frequents the rocks and stones between tide marks, and is to be found on all our coasts. They are used by some of the Scotch fishermen as bait, and are detached from the rocks with a pick or hand-digger. They are, however, not much in favour, and are only used when mussels are scarce and dear, and then the lines are baited with a variety of substitutes, as limpets, lug-worms, soft crabs, bullock's-liver, garvies, and pieces of other fish.

The late Dr. Johnstone, of Berwick, calculated that there were not less than 12,000,000 limpets used annually in that district. The supply there, however, is now almost exhausted.

The Dutch smacks use a great many limpets, and there appears no reason why our fishermen should not use them more than they do in places where they are still plentiful.

The clam (*Pecten opercularis*), known also as the scallop, is met with on sandy coasts in from 6 to 90 fathoms of water. There is a very extensive bed of them at Cockenzie in the Firth of Forth, and they are also to be found in other places in Scotland and England, and in many parts of Ireland. They are known as "frills" or "queens" on the South Devon coast, and as "squins" on the Dorset coast. They make a good bait when fresh, but, owing to their opening their shells when taken out of the water, they soon become stale. The beard of the fish, which is very tough, gives a good hold to the hook. Their use for bait is almost exclusively confined to the neighbourhood where they are found.

They are obtained by means of a dredge similar in construction to that used for oysters.

Razorfish, cockles, and periwinkles are seldom, if ever, used for bait.

Judging from the shell mounds which have been found on various parts of the coasts of our island, our prehistoric ancestors seem to have been more alive than we are to the value of shell-fish as an article of diet. At the present day, either from ignorance of its nutritive value, from prejudice, or from both, shell-fish do not take the place they ought to do in the food market of the nation.

The oyster contains as large a per-centage of nitrogenous or flesh-forming matter as an egg, each having about 14 per cent.; while the mussel follows close upon the oyster in this respect.

Dr. Pavy, in his book on Foods, gives the following relative dietetic values :—

	Egg.	Oyster.	Mussel.
Nitrogenous matter	14·	14·010	11·72
Fatty matter	10·5	1·515	2·42
Saline matter	1·5	2·695	2·73
Non-nitrogenous matter and loss. .		1·395	7·39
Water	74·	80·385	75·74
	100·	100·	100·

However digestible and nutritious shell-fish as a rule may be, it is an undoubted fact that their use is occasionally followed by deleterious effects. Some serious cases of poisoning and even death have occurred through the eating of mussels, but where such consequences have followed it has generally been traced to the improper feeding of mussels. The demand for molluscs as food is almost exclusively confined to the mussel, cockle, periwinkle, and whelk, and these may be termed the poor man's delicacy. Clams are occasionally sent to market, but the consumption of razorfish and limpets is confined to the poor people who reside at the seaside, and even by them they are not much in request.

Mr. Mayhew, in his 'London Labour and London Poor,' gives the following quantities of shell-fish sold in London as food :—

	Number of Fish.	Weight ½ bus.*	Proportion sold by costers.	Quarts.	Price.	
Mussels .	50,400,000	50,400	⅔	1,000,000	1*d.*	£ 4000
Cockles .	67,392,000	33,696	¾	750,000	1*d.*	3000
Whelks .	4,943,200	22,067	all	4,943,200	8 a 1*d.*	2500
Periwinkles	304,000,000	76,000	¾	pints 3,600,000	1*d.*	15,000

* The Billingsgate half bushel is an ordinary bushel.

There is also a good market for all the edible molluscs in the large manufacturing towns of Lancashire and the Midland counties.

The mussel (*Mytilus edulis*), although chiefly valued as a bait for the hook-and-line fishing, is also in considerable demand as food. Latterly, owing to the scarcity and dearness of oysters, it is being largely used in making fish sauces.

In the evidence taken by the Sea Fisheries Commissioners, 1879, the novel proposition was made by a fisherman at Sunderland, that it should be made illegal to use mussels for food, as it curtailed the supply of bait. And at Whitby the fishermen complained that, owing to the Boston people getting a better price for their mussels as food, there was no getting them for bait.

The cockle (*Cardium edule*) is abundant on most parts of our coasts, especially where there is sand, and upon the banks of estuaries. It is equally good raw or cooked, and may be eaten in almost any numbers with impunity. It may be boiled or roasted, eaten alone, or as a sauce to fish.

Cockles feed on the lowest forms of microscopic algæ, which they obtain by eating the sand right before them, their digestive organs being adapted to separate and absorb all the organic matter, and to expel the inorganic exactly as many species of worms do. They are gathered all the year round, and sell at £5 a ton. The cockle fishery in Carmarthen Bay gives employment to 500 or 600 families, and the cockles are worth at least £15,000 a year. Evidence was received at Furness by the Sea Fisheries Commissioners in 1879, that the cockles taken from the Kent Bank sands, in Morecambe Bay, between 1873 and 1874, were valued at £20,000.

There is a large bed of cockles at Stiffkey, in Norfolk, which are considered the best that are brought to the market, especially those of the larger kind, which have rather a lightish blue-tinted shell, and are better known as "Real Stukey." About 100 poor women obtain a living by collecting them. Cocklers generally are of opinion that the more the beds are worked the more abundant the cockles become. Complaints have been made of the destruction committed by sea-gulls on the cockle beds. It appears that since the passing of the Sea Birds Act, these birds have increased in great numbers. Cocklers aver that the birds get 1000 cockles to every quart (80 to 90) got by them. If the depredations of the gulls were materially to decrease the supply, it might be found necessary to ask the Legislature to make some amendments on the Sea Birds Act. The fecundity of the cockle is, however, so great that it is not probable that what is taken both by man and birds can have any appreciable effect in diminishing the supply.

The periwinkle (*Littorina litorea*)—winkle, London; wilk, Scotland; pinpatches, Suffolk; couvins, Scarborough—is perhaps the best known of all the edible molluscs, and is largely consumed by the poorer classes.

They feed upon the softest algæ, and are sometimes employed by the Essex oyster-growers to keep the ground clear of seaweeds. Mr. Smith, of Burnham, states that he has laid down scores of bushels every year. They are also serviceable for cleaning aquariums.

In Mr. Hyndman's report to the British Association on the operations of the Dredging Committee at Belfast (1857), we find that the periwinkles are gathered and exported to London. Mr. Getty, secretary to the Harbour Commissioners, says that this trade has been carried on for the last twenty-five years by one person, who pays £60 of wages weekly during the season.

From Kirkwall and Stromness 1000 bushels a week are exported every spring and autumn to London.

According to Messrs. Baxter and Sons, Billingsgate, the supply is about 2000 bushels per week from March till August, and 500 bushels for the remaining six months.

Those gathered from the rocks keep a fortnight in summer and a month in winter; mud-winkles will not live much more than half that time.

Whelks (*Buccinum undatum*) are largely eaten by poor people in London, where they are hawked about by costermongers and others. A large trade is done in public-houses by vendors who carry them about in baskets, and supply their customers with the use of a small saucer and seasonings of vinegar and pepper.

Razorfish (*Solen siliqua*) or spout-fish, the hose-fish of Yorkshire, burrows in the sand at the verge of low water-mark, not perpendicularly, but at an angle of about sixty degrees. It is found in Scotland and Ireland, and it is also met with in some parts of England.

Dr. Lankester, in his book on 'Animals used for Food,' relates how he succeeded in catching a number of specimens. Professor Forbes having informed him that he had only to put a pinch of salt over the mark which indicates their burrow in the sand, he resolved to try the experiment. Being somewhat sceptical as to the method to be employed, and thinking that the Professor was trying to hoax him, on the same lines that young folks are hoaxed by being told to put salt on birds' tails, he secretly put a handful of salt into his pocket, and wandered forth to try the effect. To his astonishment, by the means referred to, he soon succeeded in obtaining a goodly number.

The usual mode of taking them is by thrusting a barbed piece of iron wire into the sand, and hooking the fish and pulling it out, or digging them out with a lug-worm spade.

Razorfish are said to make nice fish sauce, and have the flavour of shrimps. They are also eaten fried and stewed.

Limpets (*Patella vulgata*) and clams (*Pecten opercularis*) are occasionally used as food in the districts where they abound. Limpets are seldom sent to the market, and the trade done in clams is unimportant.

Both are very palatable when stewed or boiled.

The principal sources of mussel supply are Boston, Lynn, Hunstanton, estuary of the Tees, Bridlington, Starcross, Teignmouth, Instow, Morecambe Bay, the Ytham, Montrose, St. Andrews, Firth of Clyde, and they are also imported from Ireland, Holland, and Hamburgh.

Morecambe and Carmarthen Bays and the Wash furnish the principal supplies of cockles.

Whelks are mostly caught off Ramsgate, Whitstable, Herne Bay, and Harwich; in the Pont (Essex), and at Lynn, and other parts of the Wash.

The market is principally supplied with periwinkles from the north and east coasts of Scotland, the Orkney Islands, the Shetland Islands, the Hebrides, and Ireland, and a few are also imported from Holland.

There is no trade to speak of done in clams, razorfish, or limpets; they are nearly all consumed in the localities where they are found.

Among the various agencies that have been instrumental in bringing about a scarcity of mussels, none is more reprehensible than the taking of them for manure. Hundreds of tons of young mussels are destroyed in this way. In the evidence received at Morecambe by the Sea Fisheries Commissioners, 1879, one witness stated that he had seen thirty or forty carts sent by farmers getting mussels, and many of these carts made two journeys.

Fishermen themselves have also contributed in no small degree to the present state of matters. Whenever the existence of natural scalps becomes known, and there is no legislative restriction to prevent them, they generally dredge the place clean, taking up small and big together, and leaving no breeding mussels to propagate the supply.

The writer would recommend that it be made a penal offence to use mussels for manure. At the size that they are usually taken for this purpose, it may be assumed that one ton represents from five to twelve tons of what would ultimately become either bait or food.

Fishermen who supply themselves from natural scalps which are under no jurisdiction should be compelled to riddle the mussels through an inch or three-quarter inch sieve, and return the undersized to the scalps. Where regulating orders are found to have failed in producing beneficial results, they should be revoked, and the scalps thrown open to the public. They would then come under the proposed riddling regulation.

So long as there is no appreciable decline in the quantities of cockles, periwinkles, whelks, and other crustacea, it is not desirable to interfere with the present arrangements by which the markets are supplied. Cockles and periwinkles are unsaleable if they are undersized, so that there is little fear of either being exterminated. Although there is not much complaint of any scarcity of whelks, catchers should return all the small ones to the sea.

The Clam and Bait Beds Act of 1881 was passed with a view to restrict or prohibit the use of the beam-trawl where it is found to be injurious to bait beds.

By adopting the measures suggested for the protection and preservation of the existing mussel scalps and young mussels, a very great and appreciable increase in the supply of mussels would follow.

Although very much might be accomplished by the system of management indicated with the existing scalps, there would still be a shortcoming of supplies.

To provide fishermen with an adequate supply of mussel bait, and procure for the public an abundant supply and variety of the edible molluscs, the writer would recommend the establishment of shell-fish farms at all eligible sites along our coasts. In order to meet the public demand at reasonable prices, one important consideration in the scheme would be to have the sources of supply at convenient distances from the markets.

There are few stretches of our coast-line where the cultivation of one or other or several of the edible molluscs indigenous to our island could not be carried on, but if shell-fish farming is to become one of our industries, people must go in for it on lines parallel to those on which the agriculturist conducts his operations. A border agriculturist, a well-known character in the district to which he belongs, was one day asked by a friend how his crops were. "Well," said he, "they have had all that man can do for them, and a fair share of God's good providence, and they are looking remarkably well."

When man extends the same care and attention to the foreshores and bed of the sea as he does to the land, then we may expect commensurate results.

An acre of foreshore as carefully cultivated with mussels as an arable farm will yield £108 every second year.

A basket of mussels spread out on the flat (and with ordinary care and cultivation they would grow quite as thick) measures 4 feet square. There are 24 or 25 such baskets in a ton; $25 \times 16 = 400$ square feet to the ton: there are 43,560 square feet in an acre; $43,560 \div 400 = 108\frac{9}{10}$ tons, at £1 a ton.

The writer had occasion to inspect a part of the north-east coast last autumn, with a view to the establishment of a shell-fish farm. The place is in every way well adapted for the purpose, but, owing to the difficulties in the way of obtaining a grant, the scheme fell through. Mussels in all stages of growth cover a considerable part of the rocks, shingle, and shore, and there is a plentiful supply of fresh water, so situated that a complete and inexpensive system of irrigation could be easily established.

Lying adjacent is a stretch of several acres of sands, which are literally alive with cockles and razorfish. In close proximity there is also a ridge of rocks well covered with periwinkles and limpets.

There are many such bays and estuaries around our coasts, which might be made a fertile source of bait and food supply, and the cultivation of which would yield a good return for the investment of capital.

It is scarcely necessary to refer to or specify any particular localities as sites for farms. The fecundity of shellfish is so great that the amount of spat voided is almost beyond computation. This being carried by the sea currents in all directions, where there are no indications of molluscan life in some form or other, the natural conditions for its existence will be found awanting.

Mussels have a great many natural enemies, among which may be mentioned the dog-whelk (*Purpura lapillus*), the starfish or five fingers, sea-birds, and crows.

There are also storms, silting, accumulations of mud, frosts, and liability to destruction by poisonous and other deleterious matters contaminating the water, which are all sources of annoyance and anxiety.

The dog-whelk (*Purpura lapillus*) perforates a small hole in the shell of the mussel and sucks out the finer parts of the fish, the valves then open and the sea washes out the remainder of the mussel.

The starfish clutches the shell with its fingers, and extracts and devours the fish by inserting its mouth into the shell.

Crows seize the mussel, and, flying up into the air, drop the bivalve on the rocks or hard ground, and so break the shell and get at the meat.

Some sea-birds pursue the same method as the crow, while others swallow the mussel whole and eject the shell after the meat has been assimilated by the stomach.

The only way to prevent destruction by the dog-whelk and starfish is to inspect the beds frequently, and remove them. A close look-out should be kept for the spawn of both, and when found it should be destroyed.

At Boston, during an easterly gale in 1874, 195 acres of mussels were killed in one night, and frosts have on more than one occasion destroyed the mussels at the same place.

In 1827, according to the late Dr. Christison, of Edinburgh, no fewer than thirty cases of poisoning occurred at Leith from eating mussels. They were supposed by some to have been rendered deleterious through feeding on the spawn of the starfish, which is poisonous, and by others through their fattening on putrescent sewage matter. Mr. Buckland, in his remarks on 'Pollutions affecting Fish Life in Estuaries,' mentions several cases where mussel scalps have been destroyed by pollutions from sewage, and also by the discharge from chemical works.

The shell-fish farmer may lay his account with having to contend with some of the foregoing drawbacks. Most of these later-mentioned difficulties, however, may be minimised by the judicious selection of a site for a farm.

Most of these drawbacks apply more or less to the cultivation of the other edible molluscs.

The bait famine is not confined to our own country,' the same state of matters is to be found in America. Professor Baird, of the United States Fishery Commission, suggests as a remedy the building of large refrigerators at the principal fishing stations along the coast. These could be filled when bait is plentiful and cheap, and the supply kept until such times as it may become scarce.

It will be time enough to resort to this expedient in this country when we have exhausted all the more economical measures to increase the supply by growth and cultivation.

In the appendix to the Sea Fisheries Report, 1879, Mr. Buckland mentions several things that might be tried as substitutes for the baits now in use, and also suggests the salting of mussels and the trying of artificial bait.

The French system of cultivation known as the "stakes and wattles" plan, as carried on at Esnandes, Charvon, and Marsilly, has often been suggested as a solution of the mussel-bait difficulty.

The expense connected with the working of it, the doubtful result of this system of cultivation in this country, together with the low prices obtained for mussels here, are against practical men trying this scheme.

Stakes planted on the Esnandes principle would give 6 × 4 or 24 square feet between each post. Utilizing this space to the best possible advantage, no more could be grown than on the flat; thus 43,560 square feet, or an acre, would require 1816 stakes. Stakes are 12 feet long, say by 4 inches diameter, 6 feet of which are driven into the ground. Poles 12 feet long by 4 inches diameter sell at 16*s.* per 100 lineal feet: 1816 × 12 × 16 ÷ 100 = £174 6*s.* 8*d.* At the lowest calculation the cost of wattles and driving the stakes into the ground would bring the expense of the bare plant on which to grow one acre, or 108 tons of mussels, up to £200.

There would necessarily be an immense deal of labour connected with the system of cultivation, and the keeping up of the plant would be a considerable item. After paying all working expenses and interest on first outlay, there would be very little, if anything, left for profit. There is another important feature of the mussel culture at Esnandes which should not be lost sight of. A very small crustacean swarms the mussel fields for six months of the year, and it is conjectured that this animalcule plays an important part in the success of the fishery.

The scheme on a small scale might work with fishermen in particularly well-adapted localities, where all the operations could be carried on by the fisherman and his family during spare hours, and where mussels grow naturally to a fair size.

The usual price for mussels off the scalps in this country is 20*s*. a ton, at Esnandes the price is 35*s*. a ton.

There are no hard-and-fast lines that can be laid down for the cultivation of molluscs, and as far as the writer is aware, there has been no systematic series of experiments carried on for a sufficient length of time to determine the relative importance of the several causes of growth and development. There are many different influences always at work, which could only be determined by careful observation and recording of experiments. In fact, the farmer should take note of everything from which he can expect to derive any advantage, and should record his observations from day to day. Methods must not be inflexible; they should be capable of modification to suit different natural conditions. These conditions vary necessarily with the locality, climate, nature of the soil, and the character and distribution of salt and fresh water currents.

Different systems of cultivation (if the term may be applied) are practised in different parts of this country. While all growers of mussels appear alive to the benefit of having an admixture of fresh water, and also of having their scalps as long as possible covered with water, very few, if any, pay much attention to this latter requisite condition for growth and fattening. As soon as the spat has attained sufficient size, the usual practice is to dredge it from a depth of 10 to 15 feet at low water, and transplant it to places where it is left for hours without any water over it.

To enable the farmer to have his produce always covered with water, it would be necessary to adopt the parking or claire system, as in vogue with French oyster growers.

The way to accomplish this would be to select a site where, by building a low sea-wall or embankment, a large area of foreshore would be enclosed so as to retain about a foot of water at low tide. The place selected would necessarily require to be very flat, in a well-sheltered position, with as narrow an opening to the sea as possible. There are places of the description indicated around our coasts which seem almost formed by nature for the purpose. The material used in the construction of the wall or embankment would depend very much on the character of the place selected. A series of walls or divisions could be introduced inside the outer embankment where the area enclosed was a large one, and the level would not suffice with one wall. This would form a series of water terraces, as it were.

The same end might be attained on a smaller scale in flat, well-sheltered positions, by puddling dykes with clay, straw, stakes, and stones, and forming convenient-sized parks and ponds on the foreshore.

A third plan would be to select a site of waste land or links below high sea-water level, in close proximity to the sea, and connect it by means of pipes or water-courses. The admixture of fresh water in either of these schemes could be effected by an inexpensive arrangement of water-courses and sluices.

Most of the operations connected with the cultivation could be carried on in light, flat-bottomed boats, or the farmer might prefer to arrange his park so that men with sea-boots on could attend to the beds.

The expense connected with the carrying out of any of the foregoing schemes would necessarily vary according to the natural advantages or disadvantages of the site chosen for operations. When we consider, however, that an acre of mussels properly cultivated will yield £54[*] a year, there is a large margin left for plant and working expenses. By selecting a favourable site for a field of operations, and expending say £400,[†] the bare cost of the plant for two acres on the Esnandes principle, it might be possible to enclose in the way indicated 30 or 40 acres, or even more.

Objection may be taken to the above systems on account of the liability of mussels to silt up and get choked with mud accumulating, but by the use of harrows made with whin-bushes this could be obviated. In the French oyster parks and claires they are applied for this purpose, and used with the back-going tide, and are found to answer the purpose. In farming mussels on any of the above plans a stock of breeding mussels would require to be kept in pure sea-water. Good stout stakes, or branches of trees chained together and anchored to the bottom, would serve the purposes of spat-collectors. Some years ago upwards of 100 faggots were laid down at Boston for this purpose, but they became so covered with green seaweed, that they were useless as collectors. This in all likelihood arose from them not being in a sufficiently strong current.

[*] See p. 426.

[†] See p. 429.

Herr Adolphe Meyer says boughs of elm and other trees are laid down in the Bay of Kiel, and taken up at the end of three, four, and five years, between December and March, being then covered with fine mussels. In the Report of the United States Commissioner of Fish and Fisheries, published in 1882, Professor K. Möbius states: "The cultivation of the mussel can be profitably carried on in all the sheltered bays on the western part of the Baltic. The best method is to use trees with all their branches, about 6 mètres high. The lower end of the trunk is pointed, and rammed deep into the bottom of the sea, so that the waves cannot uproot it. The top of the trees must not protrude above the surface even at low water. The latest time to set them is about the middle of June, as during the second half of this month the young mussels leave their eggs, swim about in the water, and soon stick to any hard object they find. After three to five years the mussels are large enough for market. During the winter months the mussel trees are lifted. After the harvest has been gathered they are set again as long as they last."

It would depend a good deal on the situation chosen for spat-collectors (which should be determined by the direction of the sea currents) whether the spat would grow to a sufficient size to admit of transplanting to the parks for feeding and fattening. It might be necessary to have an intermediate park, but this would be a matter for the farmer's consideration. To maintain a regular and constant supply of mussels a system of rotation would require to be carried out, the exact lines of which could only be determined after a series of experiments. For example, it might be found more advantageous and profitable to transplant, and to add to or diminish the relative quantities of fresh and salt water at certain stages of their growth.

The character and nature of the soil is an important consideration in selecting a site for a mussel farm. As with land, so it is with water—the same principles prevail. A given quantity of water can only support a given amount of animal life. The mussel being herbivorous and insectivorous in its habits, too hard ground is not suitable for its growth and development. It must not, on the other hand, be too soft, for mussels naturally form mud themselves, and are liable to be choked and destroyed by accumulations. Clay marl intermixed with sand is perhaps the best ground for scalps, although a stony bottom and even solid rock will suffice, provided there are all the necessary elements of sustenance and fattening present. Wherever there is a substratum of cockle and other shells, the mussel attaches itself very readily. Soft ground can be made solid and serviceable by spreading sand and gravel over it.

At some of the oyster establishments in France, where the mud is very soft, they use pattens made on the principle of snow-shoes.

By the parking system nearly all the natural enemies of the mussel can be dealt with, and the chances of deterioration and destruction from extremes of heat and cold, and accumulation of mud are very much lessened. The great advantage, however, is the comparatively short time that the mussel takes to grow to a marketable size and fatten.

Mussels under cultivation should be fit for use in from fifteen months to two years.

Carrying out the farming idea in connection with the cultivation of mollusca, and looking for a field of operations, the farmer would endeavour to get a large area of sands stocked with cockles, and if possible with razorfish, lying contiguous to his mussel parks. If clams, whelks, limpets, and periwinkles were to be had in the neighbourhood, so much the better. He would require to reside at or near the field of his operations, and have a certain number of regular hands employed. A man-foreman and half-a-dozen lads, who should inhabit the same house, so as to conveniently work to suit the tides, would answer the purpose best. Crab and lobster fishing would be a valuable adjunct, and find occupation for the hands when not otherwise employed.

Provided the cultivator has an adequate knowledge of the habits and instincts of shell-fish, he should not tie himself down to any hard-and-fast lines, but, using as far as he can the methods already employed in their systematic cultivation, he will for the rest have to be guided by his own judgment and daily observation. Many useful theories and analogies can be deduced from a knowledge of agriculture.

By adapting these to the different conditions and circumstances of growth and development, and by careful observation from day to day, the farmer of mollusca would soon become acquainted with his business. Any one going into this business would do well to have an aquarium in which he could carry on experiments and conduct investigations. The time and trouble given to this in a methodical and systematic manner would well repay itself.

Any gentleman whose tastes lie in this direction, and who is fond of outdoor exercise and country life, would find shell-fish farming a genial occupation, and one where he would get a better investment for his capital than in an agricultural farm.

With his fishing-yacht, hand-lines, and gun, and a few lessons from the taxidermist, there would be very little room for complaint on the score of dulness.

The systems of cultivation as proposed by the v would not preclude fishermen from going into them. Where suitable sites for mussel culture are to be met with, in the neighbourhood of fishing colonies, they could either individually cultivate their own patches, or form themselves into clubs or associations for this purpose. There are always a number of superannuated men in all fishing communities who would be glad of the employment mussel culture would give them.

It must be patent to every one that the cultivation of shell-fish as an industry has not developed in the same ratio as other branches of our sea fisheries, and it may safely be asserted that this is in a great measure owing to the want of sufficient facilities to enable the public to cultivate the foreshore and bed of the sea.

The Sea Fisheries Act, 1868, 31 & 32 Vict. (repealing and superseding the Oyster and Mussel Fisheries Act, 1866, 29 & 30 Vict., c. 85), was passed with the object, among others, of encouraging and facilitating the establishment, improvement, and maintenance of oyster and mussel fisheries.

By this Act, under which a private right can be conferred on an individual in the same manner as by charter from the Crown, any individual or company desirous of establishing an oyster or mussel fishery may apply to the Board of Trade for an order giving authority to do so.

The following is the mode of procedure:—

A site for a mussel farm having been chosen, the first step is to find out whether the adjoining landed proprietor or any one else has any vested rights or interest in the part intended to be applied for.

If there be any vested rights or interest in private individuals or corporations, there should first be an arrange-ıt come to with them as to terms of lease, rent, &c.,

before applying to the Board of Trade. The applicant must transmit to the Board of Trade a memorial, giving a description of the existing condition of the proposed fishery, of the manner in which it is intended to cultivate it, a statement of the proposed capital to be invested, and the arrangements, if any, made with the adjoining proprietors.

There are also plans, maps, and other information required. After the memorial has been considered by the Board, particulars of the proposed fishery are advertised, and a day fixed for hearing evidence for and against the scheme. An inspector from the Board of Trade attends the inquiry, and reports thereon, and the applicant is apprised in due course of the result.

The Board of Trade publish a pamphlet (which can be had on application to the Secretary) for the guidance of persons applying for fishery orders under Part III. of the Sea Fisheries Act, 1868.

The pamphlet, however, does not give any definite information as to the expense incurred in procuring a grant of fishery order. The fee charged by the Board of Trade is £35, and other £35 must be deposited for inspector's expenses; the balance, if any, of this latter sum is, however, returned. There are also the expenses of preparing memorandum, draft order plans, and advertising. Over and above this the applicant must be prepared to meet the expense of any objections to the scheme.

In obtaining the order for Holy Loch and in the measures first taken to give effect to it, Mr. Hunter spent £700, and although Messrs. Pennell and Hall in their report on the oyster and mussel fisheries state this evidently as an extreme case, still any intending applicant would not lose sight of this in his calculations as to the expense he might possibly be put to in obtaining an order.

A perusal of the returns of applications for grants of orders between 1869 and 1879 is anything but encouraging to those who might be disposed to invest capital in the cultivation of shell-fish. It appears that out of thirty-four applications, six were refused, seven were withdrawn, six had been revoked, and one was pending. (See Appendix.)

The length of time that an applicant is often kept in suspense after making application for a grant is most unsatisfactory. A good deal, no doubt, depends on the time of the year when the application is made, the nature of the application, the opposition made to it, and the nature of the modifications considered necessary by the Board of Trade; but, notwithstanding, there is an unnecessary amount of time often lost before a decision is given.

Depredations are often committed on mussel beds by impecunious persons, and these the present law has no means of dealing with.

The ceding of large and unmanageable tracts of foreshore and bed of the sea has exerted a very prejudicial influence on the development of this branch of our sea fisheries. (See Appendix.)

Landed proprietors, corporations, and others have had large areas of the sea and shore made over to them, which they have in some instances made little or no attempt to cultivate in a systematic and practical way, and the result being a failure, has no doubt deterred many from attempting smaller and more manageable schemes.

The principal obstacle to the working of Part III. of the Sea Fisheries Act, 1868, is stated by Mr. Farrer, Permanent Secretary to the Board of Trade, in his evidence before the Select Commissioners on the Oyster and Mussel Fisheries, 1876. On p. 3 he says:—" Then there was another important alteration in the Act of 1868; power was given, as in the former Act, to take land above high water-mark compulsorily for the purpose of the fishery, but where there were any rights below low water-mark, on the bed of the sea, there it was provided, by a clause inserted in the Bill in the House of Lords, that these orders should give no power whatever, and as there exists a number of rights, some very clear and some very shadowy, over the foreshores and bed of the sea, under all sorts of feudal grants, and charters, and prescriptions, it is a question to say whether that restriction may not have had a very injurious effect in preventing people from applying for orders, and in preventing the grant or due operation of such orders."

Mr. Farrer further states in the same examination :—

"Grants have been made from time to time by the Duchy of Cornwall, who there possess the bed of the sea, to local proprietors, and I am told by the inspector that he fears these orders will never get through, in consequence of the impossibility of dealing with those rights."

These remarks do not apply to Scotland, the law of which differs from that of England respecting foreshores. In England "the common law right of the subject to go upon the shores of the sea, between high and low water-mark, only applies to places where no exclusive right is vested in an individual."

. . . . "An exclusive right to the shore may belong to a subject, though *primâ facie* it is in the King (Bagot *v.* Orr, 2 B. & P., 472)."

In Scotland, however, the foreshore is part of the patrimonial estate of the Crown, and the royal right extends not only to the shore between high and low water-mark, but out into the sea as far as the line which defines the limits of the British Empire. (See Duchess of Sutherland *v.* Watson, Jan. 1867, 6 Macph. 199.)

In Scotland, then, where no mussel or oyster fishery exists, and where a grant of oyster and mussel fishery has not already been made, applicants for fishery orders require only to deal with the Board of Trade under Part III. of the Sea Fisheries Act, 1868.

Although this is the case, no one would think of applying for a grant of fishery order where the adjoining proprietor (especially if he were an influential one) was adverse to the scheme. The reason of this is obvious. One would never know what was to be the cost of meeting the objections, and there would be the chance of such modifications being considered necessary by the Board of Trade as might make the scheme practically unworkable.

Unfortunately a grant of fishery order for Scotland, for cultivating other molluscs than mussels and oysters, cannot be obtained. In Scotland "the right of taking limpets, cockles, whelks, and similar small shell-fish, below high water-mark belongs to the public, and being vested in the Crown, not as a private right, but as a popular privilege, it is incapable of grant to, or appropriation by, an individual. Neither express grant, nor exclusive possession, following upon any kind of title, can exclude the lieges" (Stewart's 'Rights of Fishing,' p. 71.)

In England a grant of fishery order may apply to any kind of shell-fish that the applicant may care to cultivate.

Although in England a party may obtain a lease from those who have vested interests in the foreshore and bed of the sea, in order to obtain protection it is necessary to have a grant of fishery order from the Board of Trade.

The ever-growing wants of the fishing community, and the incessant requirements of the public food market, make it imperative that there should be a reconstruction of the whole law on the subject of grants of fishery orders.

As an illustration of what has been accomplished in France by the liberal legislative measures of the Government, the statistical details show that in 1873 there were 2564 shell-fish establishments, in three years after they had increased to 13,526. Although these figures relate principally to oyster cultivation, it does not materially weaken the argument in favour of liberal legislation being essential to the development of the resources of the sea and shores.

How the difficulty respecting the foreshores and bed of the sea is to be dealt with is more a matter for the lawyer than the writer of this essay.

The acquiring of the foreshore and bed of the sea for the cultivation of mussels and other molluscs should be placed on such a basis that the public could rent it in the same way as a piece of land. The unravelling of all matters connected with proprietors' claims and interests in the foreshores and bed of the sea, and the preliminary inquiries respecting the rights of navigation, and the curtailing of public rights and amenities, must be dealt with, and settled, and clearly defined independent of the applicant, before we can hope to see the public embark in this new industry of shell-fish farming.

What is required is that a regular lease be granted by the Board of Trade or other Government department, by which the lessee undertakes to pay a stipulated sum per annum for such a series of years as may be agreed upon, and to conform to such conditions as the Government may see fit to impose. The conditions of tenure as to rent, length of lease, and system of cultivation, would require to be of a liberal and broad character, so as to induce people to invest capital in what is as yet a comparatively unknown business in this country.

With the information in the possession of the Board of Trade, embodied in the reports of their inspectors, there would be no difficulty in preventing an occurrence of the existing abuses and amending present defects in any fresh legislation on the subject.

In the Firth of Forth orders have been obtained, and no attempt has been made to cultivate some of the allotments. Here and on the Norfolk coast and elsewhere, far too large areas have been ceded for them ever to receive that attention which is requisite for successful cultivation.

Unless a very material improvement has taken place in the Boston and Lynn mussel fisheries since Messrs. Pennell and Hall issued their report in 1877, the regulating orders for these places should be revoked. The writer is in favour of doing away with all regulating orders and compelling fishermen to riddle their mussels through a sieve, the size of which should be determined by the fishermen located in the districts where the scalps exist.

The defective working of the protection clause could easily be obviated by inflicting the same scale of imprisonment on impecunious persons as is meted out to offenders unable to pay the fines under the Tweed Act. For the first offence a person may be committed for any period not exceeding two months, for three months for the second offence, and for four months for the third.

The system of leases and rents would relieve the applicant of the often excessive expenses that he has to incur in procuring a grant of fishery order, and there would be no such delay as now often keeps the applicants for months in suspense before they know the result of their application.

In conclusion, the writer would suggest, as the best means of increasing the supply of mussels and other molluscs (oysters excepted) used either for bait or food :—

That it be made a penal offence to use mussels for manure.

That where regulating orders have failed to produce beneficial results, they be revoked.

That fishermen be compelled by law to riddle mussels through a sieve, and return all undersized to the scalps.

That shell-fish farms be established at all eligible sites around the coast, and such alterations be made in the law as will encourage and enable capitalists, large or small, to rent the foreshore and bed of the sea, the same as a piece of land.

APPENDIX.

RETURN OF APPLICATIONS TO THE BOARD OF TRADE FOR GRANTS OF ORDERS UNDER PART III. OF SEA FISHERIES ACT, 1868, BETWEEN 1869 AND 1879.

Name of Order.	Locality.	Area.	Date.	Result.
Wigton	.. ..	.. ..	..	refused
Donibristle . .	Donibristle, Firth of Forth	1120 acres	1869	revoked
Exe Bight . . .	.. ..	.. ..	..	withdrawn
Holy Loch . . .	Holy Loch, Firth of Clyde	307 acres	1869	revoked
Langston . . .	Langston Channel and Chichester Harbour .	225 acres	1869	cultivated
Loch Goil . . .	.. ..	.. ..	..	withdrawn
Boston	Boston Deeps. . . .	122 sq. miles	1870	cultivated
Emsworth . . .	Emsworth Channel . .	45 acres	1870	,,
Aberdour . . .	Firth of Forth . . .	4440 acres	1870	,,
Firth of Forth . .	.. ..	.. ..	..	refused
Buccleuch . . .	Firth of Forth . . .	5403 acres	1870	cultivated
Midforth . . .	,, ,, . . .	414 acres	1870	revoked
Edinburgh . . .	,, ,, . . .	3 naut. miles	1871	,,
Emsworth Channel	Emsworth.	300 acres	1871	cultivated
Swansea . . .	Swansea	100 sq. miles	1871	,,
Greshernish . .	Greshernish, Isle of Sky	167 acres	1872	,,
Lynn	Lynn Deeps	107 naut. sq. m.	1872	,,
Salcombe . . .	Salcombe River, Devon.	96 acres	1872	revoked
Bosham . . .	Bosham Channel, Sussex	384 acres	1873	cultivated
Menai Straits . .	Menai Straits. . . .	180 acres	1874	,,
Conway . . .	.. ..	.. ..	..	withdrawn
Paglesham . . .	River Roach, Essex . .	3 acs. 3 rds. 29 pls.	1874	cultivated
Brownsea . . .	.. ..	.. ..	..	withdrawn
Truro	Truro River, Cornwall .	1743 acres	1876	cultivated
Falmouth . . .	.. ..	.. ..	..	withdrawn
Falmouth . . .	Falmouth, Cornwall. .	.. ..	1877	cultivated
Shelford Creek .	.. ..	.. ..	..	refused
Isle of Sheppy. .	.. ..	.. ..	..	,,
Tollesbury and Mersea . . .	Blackwater, Essex . .	1599 acres	1879	cultivated
Blackwater. . .	.. ..	.. ..	..	withdrawn
Bradwell . . .	.. ..	.. ..	..	refused
St. Peter's, Blackwater . . .	.. ..	.. ..	..	,,
Wotton Creek . .	.. ..	.. ..	..	withdrawn
Hunstanton . .	.. ..	11 m. sea coast	..	pending

6 refused, 7 withdrawn, 6 revoked, 14 cultivated, and 1 pending; 19 unsuccessful out of 33.

THE BEST MEANS OF INCREASING THE SUPPLY

OF

MUSSELS AND OTHER MOLLUSCS

(OYSTERS EXCEPTED)

USED EITHER FOR BAIT OR FOOD.

"*THE RIPPLES WHISPERED TO THE MUSSELS IN THE GREY OF THE MORNING.*"

("THE GREY OF THE MORNING." Picture by John Brett, A.R.A., 1882.)

[J. C. WILCOCKS.]

THE BEST MEANS OF INCREASING THE SUPPLY OF MUSSELS, ETC.

THE common mussel (*Mytilus edulis*) is a most important shell-fish, and is becoming more and more in request both as bait for sea fish and also for food.

The increasing scarcity of the oyster, and its consequent rise in price, has caused the mussel to become in some measure its substitute, and the writer is informed that large quantities of the latter are used in place of the former in sauce for fish in London and elsewhere.

Notwithstanding that the mussel is injurious, and, in fact, poisonous to some constitutions, it still not only remains a favourite food, but the demand increases yearly.

Various conjectures have been hazarded as to the causes of the poisonous character of mussels, some persons having attributed it to the presence of the pea-crab (*Cancer pisum*) the body of about the bulk of a pea, which is often found inhabiting the mussel, and may therefore be cooked with it, when the mussels are boiled in their shells; but Pennant is of the general opinion, in his 'British Zoology,' p. 111, vol. iv., that the swelling after eating mussels is wholly constitutional; "for one that is affected by it, hundreds remain uninjured."

The afflicted person swells frightfully both in the abdomen and the head, is covered with red spots or blotches, and even death has sometimes ensued. In the case of the eating of mussels which have been gathered from the bottom of a coppered ship, the symptoms have been of the most violent character.

A quantity of milk should always be drunk by any person poisoned by mussels. The oyster has also the same poisonous effects when gathered from the walls of floating docks, where copper-bottomed vessels are constantly moored, and those dredged from bottoms of harbours crossed by mineral lodes, are also injurious, unless transported to other grounds, where no mineral lodes exist, when after the lapse of a short time they lose their injurious qualities.

As the object of this essay is to set forward the best methods of increasing the supply of mussels and other molluscs (oysters excepted) used either for bait or food, the writer appends a list of shell-fish coming under that category, p. 478.

Many shell-fish having local names quite unknown to the general reader, he thinks it well to give their appellations in both English and Latin, so that his readers may be able to recognise each kind by reference to any work on shells.

Mytilus edulis (Linn. Syst. 1157, No. 253).
THE EDIBLE MUSSEL.

The edible or common mussel has a wedge-shaped shell, round behind, the beaks forming a sharp point in front.

When the *epidermis*, or outer skin, is removed, the shell is of a deep blue colour.

It is found in large beds both in deep water and above water-mark, both in arms of the sea, tidal rivers, and also on the open coast, where, however, it does not usually attain the size it does in the mixed water of the estuaries, for the mixed water is thickly inhabited by the *Diatomaceæ*, very small organisms, forming a large amount of the food of both the mussel and oyster.

WANT OF LEGAL PROTECTION.

The great difficulty with which we have to contend in this country is, that we have no sufficient legal protection, as in France, for any shell-fish beds, where individuals have obtained concessions of the foreshores, so that they can legally exclude all intruders, and no one can disturb or remove the shell-fish, any more than he can do so with the crop on any portion of cultivated land. In his essay, "On the Utilization of Localities in Norfolk and Suffolk suitable for the Cultivation of Mussels and other Shell-fish," for which a prize was awarded at the National Fisheries Exhibition, Norwich, 1881, Mr. Charles Harding, C.E., King's Lynn, very appositely says: "The secret of the whole matter is, that where mussel and oyster culture has proved successful, the person undertaking the same has obtained a concession from the Government to work the beds exclusively himself, *and has not been hampered by other persons claiming a right to fish on his grounds;* in other words, fishings for shell-fish are worked in precisely the same way as farms on the land, where the farmer sows his seed, and at the proper season *reaps this corn.* In England the laws allow the seed to be sown, and protected to a certain extent, and when the molluscs are a certain size, i.e. two and a half inches for oysters, and two inches for mussels, the whole world is free to come and fish on the beds by taking out a nominal licence, which is at the rate of 3*s.* 6*d.* per ton on the burden of the smack for one year, or 9*d.* per ton per month.

This applies only to fisheries worked under the 'Sea [illegible]

[illegible] make the oysters and mussels the actual property of [illegible] private individual or body corporate appears at first [illegible] rather hard on the so-called fishermen; but it [illegible] borne in mind that any person who undertakes to cultivate a portion of the foreshore for the increase of mussels and oysters must be in a position to expend a [illegible] amount of capital, and therefore he would not [illegible] much manual labour, but confine his energies [illegible] employment of watchers or water-bailiffs, to the making of 'lays' or 'parcs,' by digging large reservoirs [illegible] low-water marks, and the various other expenses connected with the enterprise; so that the supply of molluscs would be greatly increased, and the fisherman or labourer employed would have more work than he has under the present exhausted state of things."

Mr. Charles Harding, C.E., can unfortunately speak from experience, for being lessee of some eleven miles of the coast in Norfolk, he has suffered extensively from depredations, in regard to which he says, "The greatest trouble I have in protecting my mussels is from a class of men who call themselves fishermen, but who are half farm labourers and half fish hawkers, and are the scum of the villages lying on the coast. I have lost from two to three thousand tons of mussels in one year by these men, which would otherwise have gone to Scotland to be used as bait by fishermen. All this might have been prevented if the Board of Trade granted a provisional order for my fishery when requested."

[illegible] could scarcely be made too stringent for the [illegible] of persons of sufficient enterprise to undertake the cultivation of shell-fish.

In the case of depredations by boats with dredges or other instruments the whole should be forfeited, and the fact of dragging any instrument over the beds should also be severely punished. All the grounds conceded for shell-fish culture should be marked out by buoys or beacon-posts, with notice boards, so that depredators could not plead ignorance of the fact of the appropriation of the ground, and the purpose of this appropriation.

This appropriation must not be conceded in perpetuity, but on lease for terms of years, on condition of the annual bringing into cultivation of a certain proportion of the area of the foreshore in question; if this condition be not complied with, the whole of the conceded appropriation to be forfeited, and to be granted to other applicants, or applicant, together with any constructions made thereon.

A penal clause is absolutely necessary, for if omitted there would be no sufficient guarantee for the ultimate cultivation of the concession, as a company or individual might obtain the grant of a very large extent of foreshore, cultivate a very small portion, and would thus have the power of excluding others more enterprising from embarking in such an undertaking.

The whole of the estuaries of Great Britain and Ireland should be looked on in the light of nurseries for the fisheries from a national point of view, and considerable portions, where considered the best adapted for the purpose, should be set aside as shell-fish farms.

ON THE CONSUMPTION OF MUSSELS FOR BAIT AND FOOD.

The consumption of mussels for bait is very large at the present day, the number of fishing boats having so much increased of late years.

For ground and long-line fishing as well as for hand-line work it is probably the most important bait used by the boats of the various fishing villages along the whole coast-line of England and Scotland and the North Sea. It is, however, valuable everywhere, for there is scarcely any sea fish which will not feed on the mussel when obtainable.

It is not used by the smacks, because their movements are not so easily controlled in shooting out the long-lines, and they require, therefore, a tougher bait, namely, the whelk or buckie (*Buccinum undatum*), to which the writer will refer in another place; but it is the great bait in use by the smaller boats, as their movements are more controllable, and the mussels are on this account not so easily knocked off the hooks in shooting the lines.

The mussel is of a very soft nature, and there are only two points in it which will hold the hook, namely, the gristle, which is attached to both valves of the shell, and the tongue, not unlike that of animals, which is seen on extracting the mussel from the shell, and spreading it open like a book.

The mussel is placed on the hook after extraction from the shell, by first spreading it open in the left hand, and inserting the point in the root of the tongue, then closing the mussel as if it were a book, the hook is passed through the round gristles, which come exactly opposite each other when the mussel is again closed, and the operation is completed.

By many fishermen the operation is reversed, namely, by commencing with the gristle and ending with the tongue, but either method is effectual. The mussels, if opened the day previous to use, become somewhat more firm, consequently the practice is much followed.

In connection with the subject of the great consumption of mussels as bait, the writer quotes the following from the essay of Mr. Charles Harding, previously referred to:—

"Mr. P. Wilson, Her Majesty's Fishery Officer at Eyemouth, in Scotland, reports that in one week the boats from Burnmouth, Coldingham, and Eyemouth, used for baiting their long lines sixty-one tons of mussels. They landed with this quantity of mussels 25,620 stone of haddocks, besides a considerable quantity of cod and whiting, and got for the fish 1*s.* 8*d.* per stone. Mr. Wilson also reports that when the fishermen are unable to obtain mussels, they have in many instances had to bait their lines with bullocks' liver, and be content with half a catch of fish."

If three villages only require sixty-one tons of mussels to bait their lines for one week's fishing, it is very evident that the collective requirements of the fishing boats of the eastern coasts of the kingdom for one week only must be very great indeed; and as this fishing with mussels in some form is followed for the chief portion of the year, the consumption must be truly enormous.

It is therefore no matter of surprise that the great demands on the beds, are resulting in a gradual scarcity of mussels, and it is therefore imperative that every means should be taken to increase the supply.

The quantity used for food, is also very large, and, in consequence of the increase of rail accommodation, they are carried all over the country. From one river alone, the estuary of the Exe, in Devonshire, the South-Western Railway Company, the writer has been informed, have received as much as £2000 during one year for the carriage only of mussels!

There is a considerable trade in mussels also from Teignmouth and Dartmouth, also from Appledore, and from Instow Station, close to the estuary formed by the united Taw and Torridge rivers. On the continent the consumption is very large indeed, for from Antwerp to Paris only, for 1873, according to the statistics of the *Halles Centrales*, the value amounted to 7,000,000 francs, or £280,000, all which came from natural beds. From the coasts of France also very considerable supplies are obtained.

OF THE CULTIVATION OF MUSSELS.

The best, and in fact the only, means of increasing the supply of mussels is clearly by cultivation, inasmuch as nature itself will not any longer suffice to supply spontaneously quantities equal to the demand.

Three methods may be adopted in mussel culture, the British, the French, and a combination of the two.

THE BRITISH METHOD.

The British method is of very old date, and consists of the removal of the mussels of various sizes from the channels in the lower portions of tide-rivers, or from banks in the same, and occasionally from the open shore, to other portions higher up the estuaries, generally between tide-marks.

THE FRENCH METHOD

Is altogether different from the British, consisting in intercepting the spawn or spat of the mussel by artificial means, namely, by wattled palisadings, which catch the spat, or spawn, as it drives along with the currents. The method is at least six hundred years old.

THE COMBINATION METHOD.

This would combine the two above-named methods in one, by encircling artificial beds, or mussel scalps, or scoops, with posts and wattlings, or erecting lines of these wattled palisadings across these beds, for the interception of the ova of the mussels when extruded, as they drift with the tidal currents, by which combined method large quantities would be saved, which in many cases would otherwise be lost.

This method would not probably answer on good fattening grounds high up the estuary, as too great an admixture of fresh water with the salt is not suitable for spatting, although exactly what is requisite for fattening. A few posts and wattlings would soon test this.

REQUIREMENTS OF THE BRITISH METHOD.

Very careful selection of the ground is requisite for mussel cultivation by the British method, for if very muddy, the mussels will assuredly be choked. They are constantly laid down in beds at some miles distance from the open sea, where the bottom is hard, with a small coating of mud, and here they get very fat, probably on account of the *Diatomaceæ*, which there abound, and on which they feed.

Mr. Charles Harding says, "The most favourable locality for the permanent welfare of the embryo mussel is from five to fifteen feet above low water spring-tides, on a beach or shore consisting of sand well covered with clean sea-worn stones varying from the size of a walnut to that of a cricket-ball or larger; this makes a hard unshifting bed, not easily disturbed by the action of the sea, unless in very exposed localities."

In harbours the ground is either gravel, gravelly sand, or shallow and deep mud, on all which, except the latter, they will live and thrive. On loose sand, without stones, it is not usual to find them, and as these sands shift so very much, they would soon become covered and smothered.

They attach themselves to walls, piles, chain moorings, buoys (both of iron and wood), hulks, the posts of iron piers, and pontoons, and landing-stages, and on iron of all kinds seem to thrive uncommonly well. In places, also, rocks are so thickly covered with mussels that there is scarcely room to thrust the blade of a knife between them.

The bottom of the *Great Eastern* steamship at one time became so thickly covered with mussels that it was estimated a vessel of 200 tons could have been loaded with them.

Where they are very numerous they can be taken up with four-pronged forks, from banks drying at low water, and loaded into boats, but in shallow water, that is to say, up to 10 ft. depth, they are obtained with long-toothed rakes, having a D-shaped iron wire, or frame, at the back, to which is laced a shallow bag of stout cord-netting to retain the clusters of mussels gathered by the rake. This is a very favourite method of obtaining mussels, and, where plentiful, a boat of three or four tons can be soon loaded. In deeper water the dredge is used, with the aid of an anchor, and a winch for the cable. The anchor is dropped, and, the cable being veered out, the boat is carried by the current down stream the length of the cable, twenty fathoms or more, as the case may be, a longer or shorter cable being used according to the abundance of the mussels on the ground, or the reverse. When the whole of the cable is run out, the dredge is cast overboard, and its rope being made fast, the cable is wound in with the winch, until the anchor is approached, when the winch is relinquished, the dredge hauled in, and the cable unwinding from the winch, the boat drives back with the stream to the length of the cable.

During this time the dredge has been hauled on board, emptied of the mussels, the rubbish, as stones, &c., got rid of, and the man is ready to repeat the process.

Mussels of all sizes are removed in this manner, and carried up the estuary to the selected ground, where they are thrown overboard, and regularly spread with a fork at low water. They should never remain in heaps, as they will, if neglected, soon gather such a mass of mud as to choke themselves.

They have often been removed when too small to stand the process, and unless the mussels average quite an inch in length they should remain until at least that size.

The writer finds that, taught by experience, the fishermen more often prefer to leave them until an inch and a quarter to an inch and a half in length.

This removal of mussels is also better for those left behind, which, having more room, grow much faster than before.

Where mussels are very thickly clustered they take nearly three years to attain a marketable size, but increased space always affords increased rapidity of growth.

These artificial beds of mussels should be continually visited, and if the mud is found to be collecting too fast, they should be moved with a fork, so that it may wash away with the currents. It is utterly impossible in many places to prevent the accumulation of mud, but if the mussels by being occasionally moved are prevented from being smothered, this is all that is requisite, and a moderate amount of mud, so far from being detrimental, is beneficial, as it becomes the *habitat* of minute organisms, on which mussels feed.

The Spatting of Mussels.

From microscopic investigations which have been made it has been discovered that the embryo of the mussel can be observed in the fish in the month of December, and the spatting takes place early in the spring, continuing into the summer.

The observations made by Mr. Charles Harding, of King's Lynn, being very interesting, the writer appends the following: "On December 7, 1877, I examined some of the undeveloped embryo from a spatting mussel with a microscope, and found it to have a reddish appearance, and of the following shape ⬭⬭⬭ (namely, like the letter o on its side, somewhat flattened), and about the 500th part of an inch in diameter. It would not polarise, so I conclude the shell was not formed. On December 12th, 1879, I found large quantities of mussels to contain similar embryos, the weather at the time being very severe.

"On December 3rd, 1880, I found the same. The winters of 1879–80 and 1880–81 were exceptionally cold, so that it appears they are not dependent on 'heat and tranquillity' for their proper development.

"On May 25th, 1879, after a very severe winter of about nine weeks' continuous frost, I found, on one of the beds under my charge, several acres of brood mussels, about the 10th of an inch in length. In the spring of 1880 overwhelming quantities of brood were found on the scalps on the east coast of England, which might be measured by hundreds and thousands of acres.

"I do not think that mussels will spat, or rather that the spat will mature, in partially salt water.

"The only places where I have ever seen any young brood is where the water has the same degree of saltness as the outside sea, which, on the east coast of England, has a density of about 1026½; distilled water being 1000.

"Although it appears that salt water is necessary at their birth, brackish water is better adapted for fattening and growing, provided they are covered by the tide at high water. I find by experience that the most suitable degree of saltness of the water for fattening purposes is where the density of the water is about 1014.

"This likewise applies to the fattening of oysters." This density of the water is probably suitable to the *Diatomaceæ*, on which the oysters and mussels feed.

ENEMIES OF THE MUSSEL.

Star-fish Mr. Harding finds to be the worst enemy of the mussel; he says, "I have known ten acres of a thickly-covered scalp to be almost denuded in a fortnight.

"Last summer I had carted from beds under my control between two and three hundred tons of this fish, which will attack small mussels in preference to those of larger growth. It first grasps the mussel with its five fingers, and when it opens slightly to breathe and feed, it inserts its stomach, or part of it, into the body of the mussel, when I believe digestion commences, and the mussel dies and opens its shell, and the star-fish withdraws its stomach with the meat of the mussel. This operation I have seen performed in all its stages thousands of times upon oysters, mussels, and cockles. The dog-whelk (*Purpura lapillus*), the dog-winkle, the echinus or sea-egg, sea-fowl, crows, rooks, and rats, are all enemies of the mussel."

The carnivorous shell-fish above mentioned bore holes in the shell of the mussels, and destroy them. Crows have been seen to take up mussels and let them fall and break the shell, and rooks near the coast will feed both on shell and small fish.

The writer has seen them on sandbanks after the smooth cockles, and on visiting the spot soon after has found the holes of their beaks over many yards of the surface of the sand. He has also seen rooks flying with a sand-eel in their beaks.

The crows and rooks are well acquainted with the changes of the tide, and constantly resort to the banks as soon as uncovered at the ebb.

The writer here mentions another instance of their keenness of observation, as follows :—

In the month of April annually, a large kind of annelid or sea-worm comes out of the bottom, and takes to swimming on the surface, and is constantly washed on shore, and, driving up the beaches with the tide in sandy harbours, can be found with weed and other débris at high-water mark. The writer has collected these worms as bait for whiting-pollack, but found it requisite to be early on the tide, or the rooks would be beforehand, and, having searched along the line of high water, would have gathered up all the worms they could discover before his arrival, so that only by turning over the weeds carefully could any be found.

FRENCH MUSSEL CULTURE.

The French method is totally different from the English, consisting of dealing with the mussel at a very early stage of its existence.

As there are very few estuaries where mussels do not exist naturally, it follows that every year they must shed their spawn, which is carried about with the tidal currents, and if it settles on congenial objects free from mud, it, in due course of time, becomes alive and grows.

The French system deals with this drifting ova by providing fitting receptacles for it, which will shortly be described; but, first, the writer will relate the origin of the French system, which is of very considerable antiquity.

In the year 1235 a small vessel with a crew of only three men, the captain's name Walton, set sail from a port in Ireland with some sheep on board for an English port; but being driven a long way from his course to the southward, he at last was wrecked on the rocky coast near the entrance of the creek of Aiguillon, not far from La Rochelle. Here they had as much as they could do for some time to avoid starvation.

The shores of the Bay of Aiguillon consist of extensive mud-flats, frequented, as is commonly the case, with large flocks of sea-fowl; and as they were so hardly put to it for food, they set themselves at work to endeavour to entrap some of these birds.

For this purpose Walton devised an extensive system of nets, stretched on poles driven into the mud-flats, and during the night many birds were caught.

After the lapse of some time his attention was attracted by the fact that myriads of young mussels had attached themselves to these posts, and continually observing them, he found that they continued to grow, until they became of an eatable size and consequently saleable.

Seeing this was the case, he drove in more and more posts, and placed them sufficiently close to each other to enable him to interweave branches of trees between, thus forming a coarse kind of wattling or wicker-work, all which in course of time became coated with young mussels.

By this accident a most important industry was discovered, which has been persevered in ever since, as well as introduced into other localities.

At first the mussels are very small; but in fourteen months they have grown as large as a broad Windsor bean, or about an inch in length, when they will bear removal.

It is found that they grow rapidly after removal, which is done four times, and in a year they are saleable.

They are removed from the posts by hooks, and placed on the lower parts of the palisaded wattlings which are rarely or never uncovered; they are then moved to a higher position where they uncover on the ebb, and are placed at a higher level at each successive removal.

Bags of old netting are used to retain the mussels in place on the wattlings, and long before the netting is decayed they have firmly attached themselves by the filaments they have thrown out.

According to the experience of the writer, who has constantly used mussels for bait, and kept them alive in baskets, mussels will tie themselves together and to the sides of the basket in a few hours.

The rows of posts with the wattlings are called "bouchôts," and the men who attend on the fishery are termed "boucholeurs."

The mud of the Bay of Aiguillon is both soft and deep, so that it cannot be walked on, and as it is constantly necessary to pass over the mud at low water to attend to and remove and replace the mussels, Walton's ingenuity overcame the difficulty by building small flat-bottomed boats about 6 feet long, the materials four thin planks, two for the bottom and two for the sides, the prow turned up with a slope. The "boucholeur" has a long pair of fishing boots, and kneeling on one knee on the floor of the boat, with his hands on its sides, he propels it over the mud by pushing with his right foot.

These little boats are known as "acons," and some are large enough to carry two persons. A large number of persons gain a livelihood at Aiguillon, Chatellaillon, Oléron, St. Valery-sur-Somme, &c., by this industry.

In his report "On the Oyster and Mussel Fisheries of France," made to the Board of Trade, 1868, Mr. Cholmondeley Pennell gives the following particulars on French mussel culture.

"MUSSEL CULTURE AT AIGUILLON AND CHATELLAILLON.

"Aiguillon is a small bay about five miles north-west of Rochelle, the soil of which is mud of great depth and tenacity. The river Sevre Niortoise and two other smaller streams debouch into the bay.

"These furnish a constant supply of fresh water, highly favourable for mussel cultivation. The 'bouchôts' or mussel farms, which extend from the lowest mark of spring tides to within a short distance of high-water mark, are divided into two classes, viz. 'bouchôts battisses,' or those low down on the foreshore, and 'bouchôts d'amont,' situated nearest high-water mark. The former class, which consist simply of rows of posts driven into the mud, are used for breeding purposes, that is, for the young mussels to attach themselves to. The 'bouchôts d'amont,' on the contrary, are used solely for the purpose of growing and fattening.

"They consist of long lines of posts like those already described, but interlaced with boughs, 'clayonnage,' resembling that used in the construction of sheep hurdles, but coarser and much less closely woven, perhaps from two to four inches apart.

"In this clayonnage the young mussels are placed, and are secured in the first instance by being rolled up in lumps about the size of a half-quarten loaf, and roughly enveloped in pieces of old netting, which are then thrust in between the interstices of the clayonnage. The net becomes rotten in a few months, but in the meantime the mussels have firmly attached themselves by their byssus, so as to withstand the action of the waves. The 'bouchôts battisses,' are entirely uncovered by the tides about ten days out of the fifteen. Formerly the bouchôts were constructed in the form of a V, with the apex pointing seaward, but it was found that in this form they accumulated mud to an inconvenient extent, and recently a great improvement has been introduced by Mr. Bellenfant, who substituted for the V-shaped bouchôts, long parallel rows of posts from 25 to 50 yards apart, all pointing directly seawards, so that the tide makes a clean sweep of the mud as it advances or recedes.

"The V-shaped bouchôts also formerly answered the purpose of écluses or weirs.

"The posts composing the 'bouchôts battisses,' and also used in the construction of the 'bouchôts d'amont,' are large and strong, a diameter of half a foot being perhaps the most common thickness.

"The interlacing boughs average from 12 to 18 feet in length, and from one to two inches in diameter at the thickest end.

"A distance of seven-tenths of a metre, or about two feet, separates the posts, and a space is left between the bottom of the clayonnage and the ground.

"The spatting time is February and March, and by the end of May the young mussel has become the size of a lentil.

"In July it is as large as a haricot bean, and about this time it is transplanted to the 'bouchôts d'amont.'

"After remaining ten or twelve months in the 'bouchôts d'amont,' the mussel is about an inch and a half in length, and is fit for market.

"If left longer on the 'bouchôts d'amont,' they would doubless increase somewhat in bulk, but at the age at which they are now sold they are smaller than the mussels usually found on the coasts of the British Islands. In the markets of Paris a much larger mussel is in favour, and some of the mussels from the Mediterranean, which are fully three inches in length, command the highest prices."

"The mussels are sold almost entirely for consumption, and are considered wholesome all through the year; the two best months for them, however, being August and September. The price of a basket of mussels called a 'mannequin,' and containing about 96 lbs., varies from *6s. 8d.* to *8s. 4d.*"

"It is a curious fact that, except in very favourable seasons, the young mussels hardly ever attach themselves in any quantities to the clayonnage or posts of the 'bouchôts d'amont;' whilst on the 'bouchôts battisses' they literally swarm in clusters and layers one over another, presenting the appearance of swarms of bees. The layers are easily detached by the hand, peeling off almost with the ease and regularity of a roll of cotton-wool, and under one layer, may constantly be found a second.

"During the winter months the collecting posts of the 'bouchôts battisses' are carefully cleaned of the mud, weed,

&c., which may have accumulated, so as to be ready for the next year's spat.

"In the Bay of Chatellaillon, eight miles from Rochelle, and five from the mouth of the Charente, a large and thriving mussel fishery is also established, the method, soil, and cultivation pursued being in all respects similar to those at Aiguillon; the total number of concessions for mussel farms in the quarter of Rochelle is 1375, being an increase of nearly 200 over the number in 1866. The value of the produce for the three years ending in 1867 is as follows:—

Year.	Value of Produce.
1865	£28,000
1866	31,600
1867	28,080
Total in three years	£87,680

"All these mussel fisheries are believed to be stocked entirely by the natural spat from the coast, and it is not considered possible to form artificial beds, except in spots where there are mussels naturally."

"A muddy soil and the presence of fresh water are also considered essential elements for successful mussel culture."

"This is the result of the experience both at Aiguillon and other places in France where the experiment has been tried. The cost of working the mussel farms is estimated at about one-third of the receipts."

Mr. Charles Harding states that at St. Valery-sur-Somme "artificial breeding, rearing, and fattening of mussels, like those already described, and on principles akin to those which obtain in Ostreaculture, is carried on, and the success obtained is such as to be worthy of a record in the history of attempts made to utilise the unbounded wealth of food lying ready to man's hand along the sea-shore."

"Lines of wattled stakes, averaging 530 yards in length, are driven in the sand close to the fair-way, just above low-water mark. These *bouchôts de grand flot* extend over twenty-five acres."

"They serve for fixing the spat, which is floated up to them by the tidal currents, and constitute a collecting ground for brood, which are afterwards removed into shallow tanks of about fifty acres, dug out high on the strands between the tide marks."

"They are puddled with clay, and fitted with sluice-gates, The salt water in these tanks is slightly admixed with soft river water. They also serve as nurseries for the young mussels, which hang in clusters and gather on wattles. When they attain proper size for transplanting, they are removed into the *parc*, where they will grow and develop into marketable mussels. All this is being successfully carried out by M. Lemaire, who obtained from the French Government, in 1873, leave to appropriate a small strip of forty acres of the foreshore fringing the low sandy estuary of the Somme."

"The success of this short experiment was so marked, that, after an official visit paid by the Minister of Marine, Admiral Fourichon, and a number of *savants*, including M. Coste, who had predicted failure, the original concession was extended to 620 acres."

THE TWO METHODS CONTRASTED.

On very muddy ground the British method of mussel culture cannot be carried out, on account of mud choking the mussels; but the French method suspends the mussels above the mud, and is not only applicable on this soft ground, but such ground is preferred for it. It is therefore evident that, as the French method is applicable on the same ground as that from which the British method is excluded, an enormously extended area is opened to mussel culture by the introduction of the French method. This fact should recommend it most strongly to all interested in the increase of the supply of mussels either for bait or food.

THE BOUCHÔTS IN REGARD TO NAVIGATION.

It is of course certain that objections will be raised to the lines of posts and wattlings as obstacles to the navigation, but it is not intended they should cross the channels, but be confined to the banks; and the commencement and ends of the lines of posts, must be marked by poles long enough to reach above the surface at high water, to show the position of the "bouchôts" to boats or vessels passing. This provision of beaconing the "bouchôts" ought to be a sufficient answer to any who may consider the system as an obstacle to the passage of boats and vessels. The continued complaints of the insufficient supply of mussels for bait or food, and especially for the former purpose, show the existence of a very great evil, namely a want which ought to be supplied; and if this want is not dealt with in an intelligent manner, the haddock fishery in the North Sea will languish, and might possibly become almost extinct, as far as the line fishery is concerned, for want of bait.

It is quite true that other shell fish can be used as substitutes, but they can never be made adequate to fill the vacancy which would be caused by the absence of mussels, and must therefore be looked on as supplementary aids alone, for in fact the mussel has always been recognised to be the mainstay of the haddock fishery, wherever followed.

OF THE VARIOUS LOCALITIES SUITABLE FOR MUSSEL CULTURE IN GREAT BRITAIN AND IRELAND.

There is probably no estuary or natural harbour in the three kingdoms which is not naturally the *habitat* of the mussel, but owing in many cases to the partial enclosure of estuaries, and the consequent lessening of the back-water area, their scouring power has been very much weakened; and their entrances having been always partially obstructed by bars of sand or shingle, have become very shallow through the loss of scouring power by the above enclosures; and the salt water no longer having a free flow into and out of them, the conditions become so changed by the accumulation of alluvium over the former bottom, that the salt water does not reach up at all, or only covers the raised bottom for a short time at spring tides, consequently the shell fish life which formerly there existed is extinguished.

In some extreme cases, where the area of the estuary enclosed bears a large proportion to the area remaining, the bars of sand or gravel and shingle, at the entrances of estuaries of rivers, rise so high that no water begins to flow inside until half flood-tide, in which cases the alluvium accumulates so fast as to poison all the former productive ground, so that mussels, cockles, whelks, and winkles, all disappear, no matter how previously abundant.

In all localities where an accumulation of alluvium is as great as above mentioned, the salt water at neap-tides does not cover the raised bottom; it is therefore clear that such localities are no longer suitable for the maintenance of marine shell-fish life, and any attempt made to restore beds of mussels, even if placed on banks of gravel or shingle near the entrance, will not succeed, for when the experiment has been tried with mussels imported from other places, they have been found to gather mud in so great a quantity as soon to become choked and to die. If the entrance of a harbour is unobstructed, that is to say, there is as much depth in the entrance as the rise and flow of the tide at springs, the salt water will freely enter, and reach a considerable distance from the sea, in which case beds of mussels will thrive well, as they will be long enough covered with salt water, which will enable them on the ebb to experience no injury from the brackish water with which they will be covered for some time afterwards, nor from being high and dry until covered again by the returning flood-tide.

It may be fairly assumed that where mussels have formerly existed naturally that they may be again restored, if the ground has not been altered, or the water poisoned by mine water, chemical or other refuse. Mine water has a most injurious influence, hundreds of acres having been rendered quite unproductive of shell fish by it.

In mentioning the various estuaries of the kingdom, many will of course occur where mussel culture, by the ordinary British method of transplanting, is carried on, and has been in some cases for very long periods. In such of these as happen to be near the places of greatest demand, the local supply has long been insufficient, and bait has been sent a hundred miles or more. In all these estuaries, therefore, near the fishing stations, a large increase in the supply at a reasonable rate would be an immense boon to the fishermen, because they would avoid the expense of land carriage from a distance. On the east coasts of England

and Scotland, and north coast of Scotland, in the interest of the haddock fisheries, it is evident that it is most desirable mussel culture should be extended as speedily as possible, that they may receive a supply equal to their exigencies as near the homes of the fishermen as the local circumstances will permit.

The writer will commence with the county of Kent, and work northwards, premising that within a hundred miles of London probably more mussels would be used for food than for bait, on account of the nearness to the London market, where there is a large demand for mussels as food.

NAMES OF ESTUARIES OR HARBOURS.

Sandwich Haven.
East and West Swales.
The Medway.
The Crouch Estuary.
The Blackwater Estuary.
The Colne Estuary.
The Stour Estuary.
The Orwell Estuary.
The Deben Estuary.
The Alde Estuary.
The Yare Estuary, Breydon Water.
The North Norfolk Coast, from Blakeney to Brancaster.
The Wash and its Branches.
The Humber Estuary.
The Tees Estuary.
The Tyne Estuary.
The Tweed Estuary.
Tyningham Sands, Haddington.
Near Aberconn
Near Grangemouth
Near Culross
Near Torryburn } Forth Estuary.
Eden Estuary in St. Andrew's, Fife.

Near Tayport
Abreast Carse of Gowrie } Tay Estuary.
Esk Estuary or Hake
North Esk Estuary } Montrose.
Dee Estuary
Don Estuary } Aberdeen.
Ythan Estuary, Newburgh.
Ugie Estuary, near Peterhead.
Deveron Estuary, Banff.
Spey Estuary, Garmouth.
Findhorn Estuary.
Firth of Inverness.
Firth of Beauly.
Firth of Cromarty.
Firth of Dornoch.
Loch Fleet Estuary.
Dunnet Bay.
Kyle of Tongue.
Loch Eribol.
Kyle of Durness.
Loch Sandwood.
Loch Inchard.
Loch Laxford.
Loch Kylescough.
Loch Inver.

Loch Enord.
Great Loch Broom.
Little Loch Broom.
Loch Greinard.
Loch Ewe.
Gaerloch.
Loch Torridon.
Loch Kishorn.
Loch Carron.
Loch Alsh.
Loch Duich.
Portree
Raasay Sound
Loch Eynord
Loch Eishart
Loch Bracadale } In Skye.
Loch Sligachan
Scalpa Sound
Loch Follant
Loch Snizort
Loch Hourn.
Loch Nevis.
Loch Morrer.
Loch Mudart.
Loch Sunart.
Sound of Mull
Loch Mingary
Loch Achune
Loch Acharnish
Loch Tua } In Mull
Loch na Keal
Loch Scridan or Levin
Loch Laigh
Loch Don
Loch Linnhe.
Loch Eil.
Loch Leven.
Loch Creran.
Loch Etive.
Sound of Kerrera
Loch Melfort.
In the Lewis or Hebrides, twelve Lochs or Harbours.
Jura and Islay, four Lochs.
Cantire, three.
The various Branching Lochs from the Clyde.
Loch Ryan.
Luce Bay.
Wigton Bay.
Solway Firth Branches.
Ravenglass Estuary.
Duddon Estuary.
Morecambe Bay.
Ulverstone.
Hambleton.
The Lune Estuary.
The Wyre Estuary.
Mersey Estuary.
The Dee Estuary.
The Conway Estuary.
Beaumaris.
Menai Straits.
Carnarvon.
Pwllheli Harbour.
Barmouth Estuary.
Aberystwith Harbour.
Cardigan Harbour.
Newport Harbour.
Milford Haven.
Towy Estuary.
Burry Estuary.
Parret Estuary.
The Severn Estuary.
Torridge and Taw Estuary.
Camel Estuary (Padstow).
Hayle Estuary.
Helford Estuary.
Falmouth Estuary and Branches.
Fowey Estuary.
Looe Estuary.
Tamar Estuary.

Yealm Estuary.
Erme Estuary.
Avon Estuary.
Salcombe Estuary.
Dart Estuary.
Teign Estuary.
Exe Estuary.
Axe Estuary.
Fleet Estuary } Near Weymouth.
Wey Estuary }
Stour and Frome Estuary, near Poole.
Avon Estuary (Christchurch).
Lymington River.
Beaulieu River, and North shore of Solent.
Southampton Water.
Portsmouth Harbour.
Langstone Harbour.
Chichester Harbour.
Arun Estuary (Arundel).
Adour Estuary (Shoreham).
Ouse Estuary, (Newhaven).
Rye Estuary.

IRELAND.

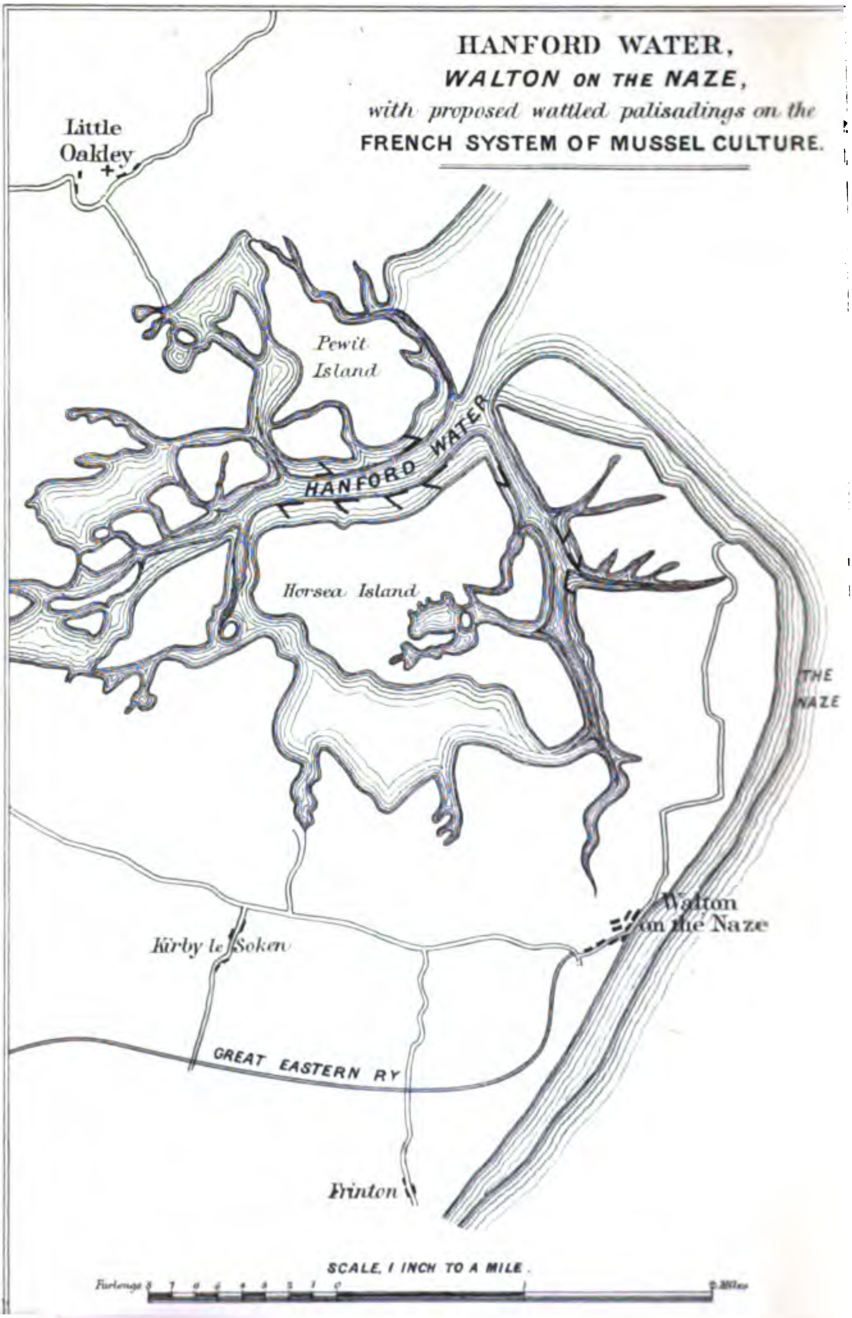
Harbours and Estuaries.

Kinsale Estuary.
Cork Estuary.
Blackwater Estuary (Youghal).
Dungarvan Estuary.
Rinshark Estuary (Tramore).
Waterford, Suir and Barrow Estuaries.
Bannow Harbour.
Bar of Loch Estuary.
Slaney Estuary (Wexford).
Arklow Harbour.
Wicklow Harbour.
Carmoyle Bank, Dublin.
Rogerston Harbour.
Boyne Estuary (Drogheda).
Dundalk Harbour.
Lough Carlingford.
Dundrum Harbour.
Lough Strangford.
Lough Larne.
Belfast Lough.
Bann Estuary.
Lough Foyle.
Lough Strabagy.
Lough Swilly.
Mulroy Harbour.
Sheep Haven.
Inishfree Bay.
Trawenagh Bay.
Gweebarra Estuary.
Inver Bay.
Donegal Harbour.
Ballyshannon Harbour.
Sligo Bay Branches.
Moy Estuary (Killala).
Rathfran Harbour.
Creeks of Broad Haven.
Belmullet (Blacksod Bay).
Achill Sound and Creeks.
Newport.
Westport.
Killeries Harbour.
Ballanakill Harbour.
Clifden Creek.
Roundstone Bay
Birterbuy Bay.
Kilkerran Bay.
Casheen Bay.
Greatman's Bay.
Casleh Harbour.
Creeks of Galway Bay.
Liscanor Bay.
Shannon Estuary.
Fergus Estuary.
Tralee Bay.

Ventry Harbour.
Dingle Harbour.
Castlemaine Harbour.
Valentia Harbour.
Kenmare River and Harbour.
Bear Haven.
Bantry Harbour.
Dunmanus Creek.
Crookhaven.
Long Island Sound.
Baltimore Harbour.
Castle Haven.
Glandore Harbour.
Ross Harbour.
Clonakilty Harbour.
Courtmascherry Harbour.

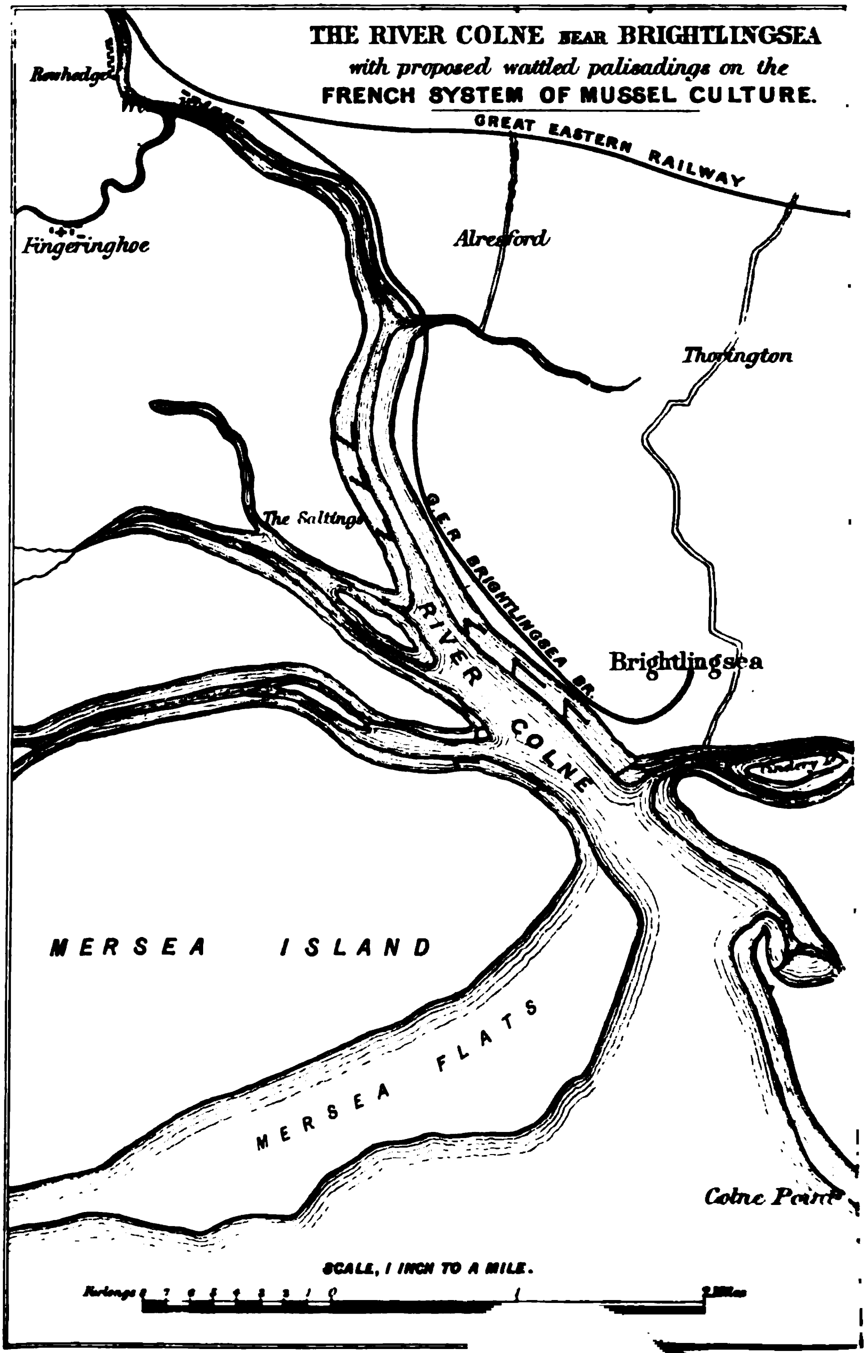
Taking only a few of the most important inlets of the sea included in the foregoing list, thousands of acres of ground could be brought into cultivation by the French system, from whence mussel culture is either now totally excluded, or only partially carried on, owing to the fact that the British method can only be applied to either hard ground, or ground where very little mud accumulates. By the French system, the mussels being supported above the mud, with a space left open between the lower part of the wattlings and the mud, these mud-flats become available to a vast extent, and if due protection be given to enterprising mussel-culturists, the writer is confident that the supply of mussels can be so vastly increased both for bait and food that no scarcity will any longer be felt, and that the haddock fisheries as well as the other white-fishing, instead of languishing for want of bait, will be maintained by its abundance.

The mussel is so vastly prolific and hardy, that if receptacles in the shape of these *bouchôts*, or wattled palisadings, be only erected in proper localities, and *kept clean* at the early commencement of the spring, the mussel spat is sure to find it, as it drives along with the tidal currents, the spat being screened or sifted from the water, so to speak, instead of drifting away, and the greater part lost, because no fitting receptacles have been provided, to which it might attach itself, and grow and thrive.

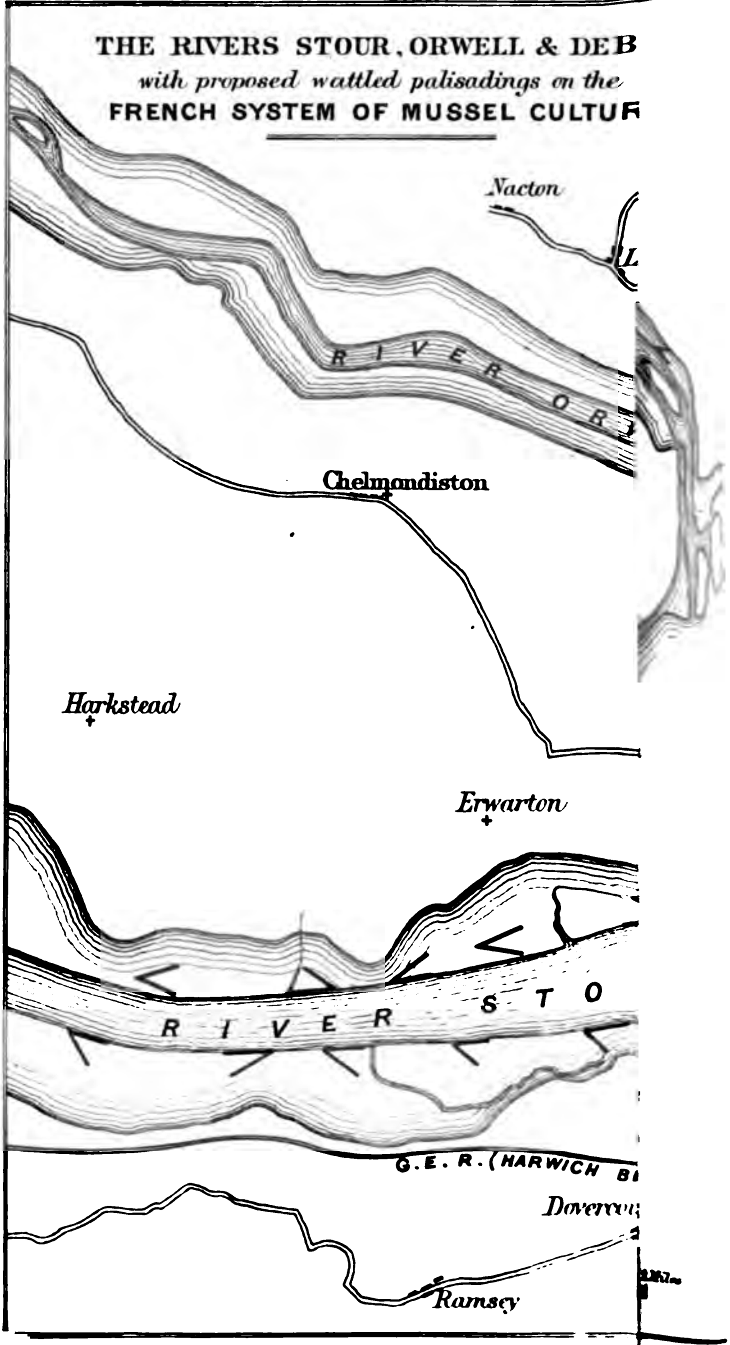


HANFORD WATER,
WALTON ON THE NAZE,
with proposed wattled palisadings on the
FRENCH SYSTEM OF MUSSEL CULTURE.

THE RIVER COLNE NEAR BRIGHTLINGSEA
with proposed wattled palisadings on the
FRENCH SYSTEM OF MUSSEL CULTURE.



THE RIVERS STOUR, ORWELL & DEB
with proposed wattled palisadings on the
FRENCH SYSTEM OF MUSSEL CULTUR



MAPS

IN ILLUSTRATION OF THE APPLICATION OF THE FRENCH SYSTEM.

The writer has thought it desirable that this Essay should be accompanied by maps or charts, showing the application of the French system to a few localities on the British coasts; for this purpose four maps, including portions of Suffolk and Essex, and the Admiralty Chart of the Firth of Tay, are sent with the Essay.

Two variations of the method are shown, the V and the palisade forms of culture in lines. On account of the narrower form of the banks, the V form has been proposed for the Stour and Orwell, the Colne, Hanford Water, the river Deben or Woodbridge Haven, and the river Ore or Orford Haven; in the river Tay, on account of the wide area of grounds the linear plan of planting the bouchôts is recommended. A personal investigation of the banks in both the Suffolk and Essex estuaries might also result in fixing on certain spots for the introduction of the linear system. In the V-formed bouchôts the apex of the V should be left open to prevent the accumulation of mud. The positions and lines are shown in V-shaped marks and black lines, and many more lines and posts in the V form would in practice be placed than can be delineated.

Both the Firth of Forth and that of Cromarty seem also specially well adapted for mussel culture on the French system; the writer, however, has sent four maps only, thinking that number sufficient for the examination of the jurors in regard to his views on the subject.

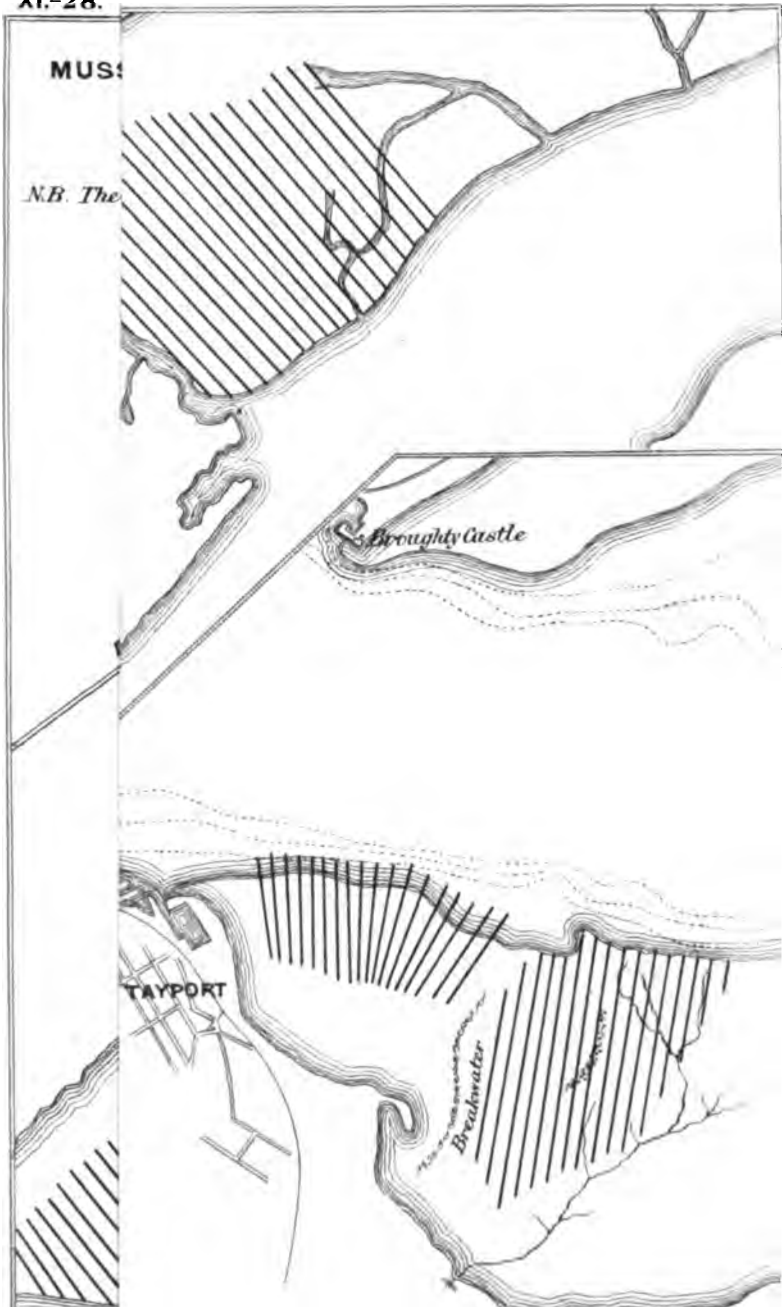
In the Firth of Tay, to the south-eastward of Port-on-Craig, the writer has chosen one position for the bouchôts, or wattled palisadings, nearly 8 cables in length, just about low-water mark, or 4800 ft., and 2 cables, or 1200 ft. wide. A passage for boats or vessels between the two groups towards the land, is purposely left open. The expanse of Monifieth Sands on the north shore invites attention, but there is great exposure from the south-eastward, and the permanency of lines of posts with wattling would seem doubtful. A line of posts, as an experiment, would be desirable before entering on extended operations here. It should be noticed that at Tayport, mussels are mentioned on the Admiralty Chart as existing at the back of the harbour already.

Higher up the Tay three groups of palisadings might be placed on the Carthagena, the Newfoundland, and other banks abreast the Carse of Gowrie. The first would be 3½ miles north-westward of Dundee, and would measure about 9 cables length, or 5400 ft., by about 5½ cables, or 3300 ft. The next group would be on the Newfoundland Bank, 8 cables to south-west, a wide opening being left for access to a space from the three hards or causeways extending from the shore of the Carse of Gowrie. The frontage of 7 cables, or 4200 ft., in width towards the shore is proposed to be divided from another group of palisadings on the Carthagena Bank by a low-water channel of about 2 cables, or 1200 ft., wide, leading up to Mr. Hunter's property. The extent of this group would be about 2 miles along low-water mark, of a long triangular form, 7 cables, or 4200 ft., wide, at the east, tapering to a point at the west end.

In connection with the salmon fishing, the writer does not recommend groups of palisadings in Inver Gowrie Bay, as a salmon batt is shown on the chart; and as regards the fishing generally, a proviso must be made in granting con-
for mussel culture on this system, that none of

XI.-28.

Plate IV.



MUSS

N.B. The

these erections are to be used as fish weirs or traps, by closing the ends of the spaces between the rows of palisades, or the open spaces between the lower wattlings and the surface of the soil. It is necessary to use this caution, as, by use of nets attached to these erections, they might be converted into fishing weirs, to the prejudice of the salmon fisheries of the Tay, or other rivers.

There are extensive mussel beds on the north side of the Firth of Cromarty in Nigg Bay; the writer would, therefore, recommend the introduction of the French system to increase and develop the supply, which would combine both systems in one.

On the east coasts of Scotland, the Forth, Tay, and Cromarty Firths, seem from the very great demand for mussels, for the haddock, and other white fishing here carried on, to attract our attention as centres of mussel culture for bait.

On the south coast of England the supply seems equal to the demand, not only locally, but a large trade is done for food to distant places. The local consumption is for both bait and food. Mussels breed naturally in Southampton Water, and an enormous area could be here utilised by the French system. At Milford Haven a very large area is available. In Ireland, Wexford Haven, Carlingford, Belfast, Strangford, and Loughs Foyle and Swilly, all have large uncultivated areas, and on the south and west coasts facilities are too numerous to mention, in regard of tillageable space.

OTHER MOLLUSCS (OYSTERS EXCEPTED) USED EITHER FOR BAIT OR FOOD.

As these shell fish in common with other objects are [illegible] under local appellations, the writer gives the Latin names in addition to assist in identification.

English Name.	Latin Name.	
Whelk or Buckie	*Buccinum undatum.*	
Winkle	*Littorina littorea.*	
Scallop	*Pecten maximus.*	
Queen or Squin (two kinds)	*Pecten subrufus, et varius.*	
Clam or Large Smooth Cockle	*Venus mercenaria.*	
Common Edible Cockle	*Cardium edule.*	
Prickly Cockle	*Cardium echinatum.*	
Smooth Cockle	*Cardium lævigatum.*	
Hen Cockle	*Venus litterata.*	
Gaper (two kinds)	*Mya truncata et declivis.*	
Razor Fish	*Solen ensis.*	
Sculpin or White Mussel	*Pholas dactylus.*	
Great Mussel	*Mytilus modiolus.*	
Limpet or Flidder	*Patella vulgata.*	
Swan Mussel	*Mytilus cygneus*	Fresh water.
Duck Mussel	*Mytilus anatinus*	

PROPOSED METHOD OF CULTURE.

With regard to the cultivation of the above-named shell fish, we are met with a considerable difficulty on the very threshold of the subject, namely that they are all more or less travellers, if we except the great mussel (*Mytilus modiolus*), which is so rarely met with as not to be of much account.

The whelk and the winkle are very great travellers, and any attempt to cultivate them would necessitate a covered enclosure.

The cultivation of the whelk, owing to its great importance to the cod fishery in the North Sea, and the demand of it for food, is a matter which would first naturally fix our attention; but the writer is not aware of any experiments having been made with it.

In the absence of any information on the subject, he would suggest the following: namely, an oblong enclosure of rough walling, two feet above ground in a sheltered natural harbour, with gravel bottom within the enclosure. The enclosure say twenty feet long, and ten wide, the greater part below the level of ordinary spring-tides, but not more than a foot. The bottom to be overlaid with rough slate or tiles, supported on bricks, two and a half inches above the ground. The tiles or slates to be set at right angles to the course of the channel of the harbour; and at every third course of their breadth, an opening two and a half inches to be left, to allow the whelks liberty to crawl where they may be inclined, in or out.

The object of covering the ground is to allow the accumulation of the eggs to take place on the under side of the coverings. The bricks should not be continuous, but only as many should be used as may be necessary to support the slates or tiles. The top of the enclosure to be covered with galvanised wire netting, projecting a foot inwards from the sides of the walls. It is quite possible this might be sufficient to prevent the escape of the whelks, but if not the enclosure would of course require to be entirely covered.

Whelks being carnivorous would require to be fed, and the food most easily procured would be the common shore or harbour crab (*Carcinus mænas*), which could be taken in large numbers in a closely-woven crab-pot, baited with any refuse fish or garbage. These could be killed by being merely chopped in two, and the whelks would soon find them when thrown into the enclosure.

The same kind of enclosure might be tried with the other molluscs, but the ground should be oozy sand, into which the whole of the scallop and cockle tribe would burrow. This ground should be a foot deep under the tiles or slates, with a stone bottom below, that they might not burrow and escape. All the cockle tribe seem to have the power of leaping as well as burrowing; but whether or not they will do so from soft ground, experiment must decide. The writer has known cockles to leap out of a dish, and Pennant refers to Aristotle's History, An. lib. iv. c. 4, on the subject, when speaking of the scallop, vol. iv. p. 99, as follows: "The ancients say that they have the power of removing themselves from place to place by vast springs or leaps."

As regards the food of any of the cockle tribe, the writer believes they partly obtain it from the soil in which they live, and partly by inhaling it from the water. As to wherein it consists, he conjectures it may be some of the multitudes of minute organisms which are always floating about and circulating with the currents.

THE BUCKIE OR WHELK,

So well known as a cod-bait in the North Sea and elsewhere, is caught in wicker pots or cages, baited either with horse-flesh or pieces of ray or skate. It is also caught by hoop-nets with the same baits, and the obtaining of this bait for the North Sea cod smacks is of itself a fishery, carried on in Boston Deeps and elsewhere in small welled smacks of about 15 to 20 tons, with a crew of three men. A good many whelks are dredged, and a quantity taken also by long lines or nets, baited with the common harbour or shore-crab (*Carcinus mænas*). No hooks are used; but these crabs are strung on the snoods, and the whelks being intensely carnivorous cluster upon the crabs, and are hauled up without difficulty.

The welled-smacks above mentioned use hoop-nets, about 2 ft. in diameter. They have 150 or more of these set, and haul them in rotation.

THE WINKLE,

As is well known, is gathered at low tide on the shore. They are not to be found everywhere; but in some large estuaries are abundant, and sometimes on the open shore. In the deep inlets or voes of the Shetland and Orkney Islands they are very abundant, and immense quantities are thence sent to England.

THE SCALLOP

Is found both in the open sea and in deep harbours. In the open sea it is constantly found in the trawls; and in arms of the sea and deep harbours is generally obtained by dredging. It is not usual to find many dry on the recess of the tide; often most plentiful in harbours in very cold weather.

QUEENS OR SQUINS.

This species has both shells convex, whilst the scallop has only the under one so shaped, the upper being flat. The queens or squins are on certain grounds immensely plentiful, and besides being met with amongst oysters, are caught in trawls by bushels at a time. They are sometimes called fan shells, from the radiate striations with which they are marked. They are also caught by dredging by people who purposely go after them. In quality, they are almost equal in taste to the scallop, and are very good food when cooked after the same manner.

They could be more often used for bait than they are and would do well for the long lines where obtainable in sufficient quantity.

Where fleets of trawlers and dredgers work, they are generally obtainable.

They could be kept alive in a walled enclosure as above described.

They are common to both deep harbours and the open sea.

THE CLAM, OR LARGE SMOOTH COCKLE.

This is a good cod-bait much used in America, and salted down in kegs for that fishery.

It belongs to the Venus family of shells, has a brown skin or *epidermis*, and is at times 10 inches round. They are much thought of in America, where clam chowder is a standard dish.

From this shell cut up, the North American Indian money known as "wampum" was formerly made, and they wore belts embroidered with it amongst the natives.

They can sometimes be obtained from trawlers or dredgers, and after a heavy gale can occasionally be picked up on sandy coasts. As a rule, they are by no means plentiful in the British Islands.

COMMON EDIBLE COCKLE.

This well known shell fish is found in the sand and oozy ground in most of our large harbours and estuaries, where flat shores or banks afford them a congenial habitation. It is immensely plentiful on some of the French flat coasts, and from Tenby in Wales also a large supply is obtained.

Not a few people get a living by raking cockles.

The mud cockle is usually smaller than those found in more solid ground.

The rough-ribbed toothed cockle is a large sea species, as large as a man's fist. The prickly cockle is about 6 inches round, and there is a smooth cockle also about the same size.

The hen cockle, another variety, is scraped out of sandy gravel in harbours; breadth 2 to 2½ inches. It is of a sweet taste, and by no means equal to the common cockle, although much eaten by the poor. The shell is thick.

THE GAPER.

Of this there are two kinds, so called because one end of the shells is always open.

Their presence is discovered by an aperture in slutchy ground, and digging in this, the fish is found in the underlying coarse gravel.

THE RAZOR FISH

Is found in sandy beaches, and up harbours on the shore in sand mixed with mud and gravel. It can travel quickly and often escapes the digger. The following two methods are, however, much preferable in procuring them.

They bury themselves in the soil in a perpendicular position, leaving a small opening at the surface, very like the key hole of a lock in shape.

Being provided with some salt, sprinkle a pinch or two in each hole, and throw a little water on it, which will carry it down on the razor fish.

This they cannot endure, and in about half a minute begin to rise above the surface to about the distance of an inch, when they can easily be drawn up out of the ground and placed in a basket.

Several dozens may sometimes be taken thus before the flowing tide again covers the ground they inhabit. Another very old method is spearing.

A barbed wire is used about 2 feet long and a quarter of an inch in diameter. Sometimes a regular harpoon head is formed on the wire. The wire is fastened through a wood handle four or five inches long, and on discovering the hole of the fish, the wire is thrust down the hole, the wire is then to be turned sideways, with a half twist, which will cause the spear head to take firm hold, when the fish may be hauled up out of its hole.

Many years since, the writer discovered a number of these wires tied up in a little fagot, and thrust up under the eaves of a thatched building, and was for some time puzzled to know their use. These were single barbed, like a large straightened fish-hook.

The razor fish is both eatable, and can be used for hand or long-line fishing.

THE SCULPEN OR WHITE MUSSEL.

These are also like the gaper, open at one end, and inhabit the deposits of peat found at many places, showing itself above the sand and shingle of the shore. It also bores into limestone and other rocks along the coast. It may be used as a ground-bait for hand or long-lines.

THE GREAT MUSSEL (*Mytilus modiolus*),

Is found only in deep water, and closing its valves on fishing lines, is occasionally drawn to the surface. It might be turned to account in ground-fishing if it were attainable in sufficient abundance.

FISH BAITS.

Pieces of herring, pilchards, mackerel, gar-fish, &c., are constantly used with much success, also the different kinds of cephalopods, as cuttles, squids, and the sucker or octopus.

SAND EEL AND LAUNCE

Are valuable baits; are caught by being dug out of the sand at low tide; they are also taken with a blunt kind of sickle, in a few inches of water, by dragging the sickle through the sand.

In the Channel Islands they are taken with a seine-net with a calico bunt to it, to prevent the fish catching their noses and injuring themselves. By this means, not being hurt, they can be kept alive for some days in floating cages, the shape of a nun-buoy, in which they are towed after the fishing-boats. This method of taking and preserving the sand eels for bait might be introduced with great advantage in the haddock and other white fish fisheries.

At Granville, in France, they get the sand eels out of the sands with a harrow drawn by a horse.

SWAN AND DUCK MUSSELS

Inhabit fresh water, and in some of them in Scotland pearls have been found.

They have been used for bait for cod in the Newfoundland fisheries.

THE INTRODUCTION
AND
ACCLIMATISATION OF FOREIGN FISH.

" *THOROUGH.*"—[W. OLDHAM CHAMBERS, F.L.S., F.R.I.B.A.]

THE INTRODUCTION AND ACCLIMATISATION OF FOREIGN FISH.

Acclimatisation as a science.

ACCLIMATISATION of Fish is the science of the distribution of the same from one district to another, and the being able to retain life in rivers, lakes, and other waters, in which the fish did not previously exist.

Selection of water.

To be enabled to accomplish this with any degree of success the first study should be to select waters resembling as far as possible those from which the fish in the first instance were taken, and to provide them with food similar to that found in their own natural waters.

Size of fish for transit.

Again, in order to render acclimatisation a success, large-sized fish should be avoided, and those known as yearlings should be chosen for the purposes of removal; but where practicable it is better to transport the ova—in proof of which may be instanced the introduction of salmon to Australia, trout into many European rivers and lakes, carp to America, &c.

A few years ago these fish were entirely unknown to the waters named above.

Pisciculture compared with land culture.

Pisciculture has very properly been called the agriculture of waters, and as we know from experience the farmer has found great advantage in cross-breeding his cattle, or improving his seeds and his roots, by introducing entirely different strains carefully selected from other districts—

also may be cited the success in acclimatising some of our game birds from one country to another; and as we know this has been the case, we may expect to reap the same advantages by a judicious acclimatisation of carefully selected fishes.

Follow natural habits, &c.

It may, therefore, be fairly assumed, that the difficulties which have attended the instances above named, would not exist with the transportation of fish, where ordinary care is exercised in following the natural habits and food of the species selected for acclimatisation.

Non-predacious fishes.

The premier thought in working out a system should be, how can we best improve our own national fishes before attempting to introduce foreign ones into our waters, and how with the greatest amount of caution we can select species not detrimental to those which are indigenous.

Neglected waters.

We have in Great Britain vast areas of water entirely neglected, that would, under proper treatment, produce a grand and almost inexhaustible food supply for the people. Many of our rivers are well adapted for the introduction of anadromous fishes, and present excellent spawning grounds, and the small tributaries are well stocked with suitable food for the young. If, therefore, salmon and trout of selected species were acclimatised therein, we should no longer find these fishes a luxury to the few, but a cheap source of food for the people.

Rhine salmon.

The writer would advise the introduction of the Rhine salmon; it is generally admitted to be one of the finest of our Salmonidæ, or with great advantage might be attempted a cross between the Rhine salmon and that of the Tay.

Salmo quinnat.

The *Salmo quinnat* or California salmon must not be overlooked, being the most productive of all migratory fishes; it thrives well in varied temperatures of water, and has extraordinary vital powers; it can sustain life under circumstances that would kill half our European fish.

Arguments have been advanced against their acclimatisation into Great Britain on account of the high rate of mortality known to exist among them; but the difficulties and dangers they have to encounter in traversing the miles of rivers before reaching their spawning grounds do not appear in this country.

Propagation.

A few years ago only a limited number of the *Salmo quinnat* were found on the banks of the Columbia River; now by aid of pisciculture the annual returns exceed one million sterling.

Commercial value.

A new and important industry in canned and preserved fish may be anticipated in this country by introducing this species of fish into our rivers, many of which are well adapted for their reception.

Land-locked salmon.

The newly-discovered land-locked salmon next deserves attention; this fish was originally considered to be a distinct species, but it is now recognised as the ordinary *S. salar*, and commends itself to us as preserving all the sporting attributes of the migratory salmon.

It would prove invaluable in some of our rivers, lochs, and lakes, severed as they are from the sea by various causes.

Introduction to England.

Through the courtesy of the Chief Commissioner for Fish and Fisheries in America, a consignment of 10,000 eggs of this species of salmon has been sent to the writer, with the expression of the hope that they may prove of value in increasing the food fishes of this country.

Hybrids.

Much has been written for and against the rearing of hybrids, and whether the cross between the salmon and the trout will reproduce is still a disputed problem; be that as it may, this fact remains unchallenged, that the progeny of the *S. salar* and the *S. ferox* are well worth the attention of the fish culturist; the marvellous rapidity of growth they are known to make in a short period of time, and the ease with which they can be acclimatised, must commend them to us as fish of great economic value.

Non-migration.

In hybridising salmon with lake trout all inclination to migrate ceases; a class of fish may therefore be produced useful in ornamental waters, lakes, or rivers, having no direct communication with the ocean. -

Rapid growth.

In making experiments of this nature we have the advantage of producing a class of fish that are very rapid growers and flesh producers; in this respect they bear an affinity with hybridised animals, and the stock can always be replenished by the assistance of fish culture.

Trout.

In offering suggestions upon the acclimatisation of trout, they must first be classified into two species, the non-migratory and the migratory; under the former division the writer would remark, that he has with great success introduced the *Salmo Levenensis* in large numbers into English rivers and waters, and it has been found that fish of this species, hatched off in February, attained the unprecedented size of 7½ inches in October, thus exhibiting a larger percentage of growth than is found in their own indigenous waters of Scotland.

Cultivation advised.

The cultivation of this fish upon an extended scale is strongly advised, and results of the most satisfactory nature may be anticipated, it having been proved beyond doubt, that the *Salmo Levenensis* will acclimatise itself in lakes and rivers where the currents are not strong, thus obviating difficulties that have arisen in selecting suitable waters for the Hertfordshire trout.

Salmo ferox.

Another fine non-migratory trout is the *Salmo ferox*, or Great Lake Trout of Switzerland; it will be found easily cultivated in this country, and the eggs can be imported in large quantities. The fry are very hardy, and no difficulty need be feared in attempting to rear them.

Many of our lakes and broads of Norfolk might with advantage be set apart for their reception. In Switzerland they attain the weight of 12 to 20 lbs.

Salmo fontinalis.

A great deal has been written in favour of the *Salmo fontinalis*, or brook trout of America; the writer has given much attention to the acclimatisation of this beautiful migratory charr, extending over a series of several years, but regrets not being able to speak in their favour for public waters; certain tributaries have been well stocked with fry and yearling fish, but they have never again been seen or heard of; the same complaint has been received from other parts of the country, and many fish culturists have given up breeding them for the above reason.

Cultivation advised for lakes.

The cultivation of the Fontinalis might, however, with advantage be attempted in enclosed waters having regular feeding and a plentiful supply of clear running water. For ornamental purposes they are not to be equalled; but in stocking public waters they cannot be recommended, on account of their great love for migration.

Cyprinus carpio.

The next fish of economic value suitable for acclimatisation is the *Cyprinus carpio*, of the Cyprinidæ family.

The culture of this fish in Europe dates back to the eleventh century, when it was introduced from Central Asia.

Species advised for acclimatisation.

The particular species recommended for acclimatisation, as food producers, are the *Cyprinus carpio specularis*, or the Mirror Carp. The *Cyprinus carpio coriaceus sine nudus*, or the Leather Carp, deriving its name from its peculiar voidance of scales, but having a beautiful thick skin; the advantage which the latter description of fish has over the former is the ease with which it can be removed from one place to another without fear of any confervaceous growth, which is created by injury to the scales.

True species.

In acclimatising this fish into England care must be observed to obtain the true species from Germany, which resemble the coarse tough bony English carp in the same degree as freshly imported mutton from the Continent resembles the delicate flavour of our Southdown mutton.

Artificial culture.

The carp is a hybernating fish, and like other members of the Cyprinidæ family is an adherent spawner ; it is well adapted for artificial culture, and can with ease be acclimatised to waters in this country and to artificial ponds and lakes.

Growth.

The carp is a very rapid grower, and will attain the weight of 3 lbs. in as many years ; but its particular speciality consists in its delicacy as a food fish. It is estimated that a 4-lb. carp will yield 400,000 ova.

Districts recommended for culture.

We have in this country many thousands of acres of land partially covered with water that for agricultural purposes are valueless ; it is therefore strongly recommended that these waste districts should be utilised and brought into profit for carp culture.

Our English and Irish farmers should be educated to the fact that under proper treatment land may be alternated for aquacultural as well as agricultural use, and to be enabled to distribute a cheap and delicious food ; fish of this nature throughout the country must in itself form an act of acclimatisation of the greatest possible service.

Recent introduction to England.

To give practical effect to the above suggestions it may be stated that the writer of this Essay has recently introduced into England a large consignment of the Mirror Carp from Westphalia, for distribution among persons willing to follow the example of their German and American *confrères*

Many years ago a great industry was carried on in this country in cultivating the shad; if therefore this fish can again be acclimatised into our waters, great benefit would accrue therefrom. It will be remembered before the days London sewage assumed its present gigantic proportions, that the Thames abounded with shad, as history informs us, at Shad Thames and Shadwell. **Shad.**

A great trade is carried on at the present day in America with the shad, and it forms one of the most important fisheries of that continent. **Foreign enterprise.**

Another very valuable food fish strongly recommended for acclimatisation is the Black Bass of Canada (*Grystes Nigricans*). This fish is well adapted for stocking many of our fresh waters, and would for sporting as well as for economic purposes present to us advantages of great national importance. **Black bass.**

The writer recently joined with others in introducing a consignment of these fish from Canada; they are at present turned off in a nursery; after a short period it is intended to place them in a well-fed pond for the purpose of propagation, and if successful the fry will be turned out into well selected public waters. **Recent introduction to England.**

A fish well adapted for acclimatisation is the Golden Tench, or Golden Schlei. This fish is extremely handsome, and is a variety of the *Tinca vulgaris*. It was first introduced into England in 1867 from Upper Silesia, where it is cultivated in large numbers. **Golden tench.**

The scales are very small, and the body is supplied with mucus the same as the common tench.

The fish thrives best in ponds with an ample supply of weeds, upon which the spawn is usually deposited.

It is a hybernating fish, and only attains growth during the summer months.

The writer can very strongly recommend the golden tench for the purpose of stocking some of our inland lakes.

National coarse fishes.

Great attention should be given to the subject of improving our national coarse fishes, and we can hardly conceive any act of acclimatisation more beneficial to the nation than the introduction of our Norfolk strains of roach, perch, pike, tench, &c., into some of the depleted rivers of our large cities and manufacturing towns.

Canals.

Again, a vast and profitable field is open to the national economist in stocking the miles and miles of canals that intersect our inland counties; there can be no practicable difficulty in rendering these waters, so to speak, arterial sources of food supply to the people.

Mussels.

It is strongly advised that the science of acclimatisation should be devoted to a more extended cultivation of mussels along the foreshores of our estuaries and rivers, which might be laid down with great advantage, not only in providing a cheap description of food for the people, but also in supplying bait for the long line fisheries, and in this respect aiding the production of an important element of our deep sea fisheries.

We might, with very great pecuniary advantage, introduce the French system of laying down beds for the cultivation of the mussels by posts and wicker-work, or, as the French term them, "*bouchôts*."

The mussel particularly recommended for acclimatisation is that known as the "great mussel" (*Mytilus modiolus*); it is extensively used in Newfoundland in connection with the cod fisheries.

Deep-sea fishes recommended for acclimatisation and culture.

In submitting an Essay upon the acclimatisation of fish, the subject can hardly be considered complete without reference is made to the subject of our deep-sea fisheries.

The writer has, during the past few months, made some very important investigations and experiments in the artificial culture of some of our deep-sea food fishes, with a view to acclimatising them along our coasts in districts where depleted fisheries require improving, or for the purpose of starting fresh industries; and proof has been made that there is no particular difficulty in artificially fecundating the ova of the cod, for which purpose an apparatus has been invented capable of hatching millions of the floating eggs of this fish; and it is here suggested that large areas of land found at the entrances to our estuaries and rivers could, at a very small cost, be utilised as nurseries for the young of these fishes in districts selected for acclimatising purposes.

Murray cod.

Another fish that would answer well for introduction in this country is the Murray cod (*Grystes macquariensis*) from Australia. An attempt was made several years ago, but the experiment was not a success. It grows to 60 lbs weight, and the flesh is considered well adapted for food.

There are many rivers in England that are not suitable for the cultivation of salmon or trout, but from the sluggishness of the waters are singularly adapted to the Murray cod.

From the slowness of its transit in the rivers no fear need be expressed as to injury to our indigenous fishes.

THE FOOD OF FISHES,

BOTH IN

FRESH AND SALT WATER,

ACCOMPANIED BY

ILLUSTRATIONS AND PREPARATIONS.

"*RANNACH.*"—[G. SIM.]

THE FOOD OF FISHES.

BEFORE proceeding with the work more immediately in hand, it is necessary, I think, to review as briefly as possible what has been done in ichthyology generally, and in the food of fishes in particular, so that we may be in a position to grasp the whole subject. Viewing retrospectively the long list of men whose names are linked to the history of fishes, the first is that of Aristotle, who was born 384 years before the Christian era, and who recognised 117 species of fishes. From the time of Aristotle forward, for nearly 2000 years, writers on ichthyology appear to have done little else than copy the writings of the renowned Stagirite. Pliny, who was born about the twenty-third year of the Christian era, wrote a history of aquatic animals, enumerating in all only some ninety-five true fishes. In the beginning of the sixteenth century we find Paul Jovius, an Italian physician, wrote a history of fishes; his name, however, is scarcely ever mentioned now in matters ichthyological. Shortly after him Bellonius also wrote on the same subject, and is credited as a man of great accuracy. Coming down to the middle of the sixteenth century, we find attention again directed to ichthyology, and that, too, by men who enquired into the matter for themselves. First, Belon, in the year 1555, Rendolitus in 1554–5, and Salviani, in 1554–8, "conferring on ichthyology a real foundation by the description and representation of a certain number of well-determined species."

Aldrovandi also wrote a history of fishes, which was published after his death, viz., in the year 1612. Merrett's 'Pinax Rerum Naturalium Britannicarum' appeared in London in 1667.

Coming down towards the end of the seventeenth century, we note the works of Willoughby, his principal object being to arrange the different species of fish "according to a plan founded upon the *distinctive characters derived* from their *organization*," which work was published by his friend Ray about the year 1675. Then we have in 1686 Ray's history of fishes, followed by a supplement in 1743. The era in which Willoughby and Ray lived is described by Linnæus as "the dawn of the golden age in natural history." Ray's memory is still cherished as that of a good man and an accomplished naturalist.

Coming on to the middle of the eighteenth century, we find Linnæus pursuing the study of nature, and bringing to a conclusion his 'Systemæ Naturæ;' he, however, appears to have but little claim to the title of ichthyologist, that is, in a practical way. His having superintended the printing of his deceased friend Artedi's 'Ichthyologia' no doubt gave him a knowledge of the subject he might not otherwise have obtained; by the exertions of the two combined, great improvement was effected in the definition of genera, including in them various accurately ascertained species. There appeared in London in 1752 an essay towards a natural history of the herring, by James Golas Dod, Wulff's 'Ichthologicae Rigni Bornissisi' was published in 1765, a work almost forgotten. Dr. Gronovius, of Leyden, wrote on ichthyology, and is said by Pennant to be an accurate ichthyologist. Dr. Borlasi's 'Natural History of Cornwall' must also be noted, as also the works of Jago. In the year 1767 Buffon appears upon the scene with his 'Natural History, General and Particular.' His history of fishes, however, is a mixture of fact and fiction. It appears evident he gave no personal attention to the habits of fishes, and of their food he says almost nothing.

Bloch's 'Ichthyologie ou Histoire des Poissons' appeared at Berlin in 1785–97; his works do not seem to have made much impression on the minds of ichthyologists at that time, and his name is almost forgotten. Leske's 'Ichthologia Lipsienses' appeared in 1794. This is another writer whose name has almost sunk in oblivion. Contemporaneous with Buffon was our own countryman Pennant, an able man and an honest one. His writings forwarded the cause of natural science much, and although now somewhat antiquated, we can look upon them as mainly the fruits of his own labours and observations. From the time of Pennant onwards, writers on ichthyology appeared in rapid succession; and in 1798 M. de Lacépède gave his 'Histoire Naturelle des Poissons' to the world. To learn the *organization* and *habits* of fishes were the objects he aimed at. Elegance and accuracy are his characteristics, and up to the beginning of the present century his works held the first place in ichthyological history.

Shaw's 'General Zoology' appeared in London in 1800, and Risso's 'Ichthyologie de Nice' in Paris in 1810. Coursing along the stream of time, we find in the early years of the present century a brilliant luminary shedding radiance over Europe in the person of the great Cuvier, who at that time was pushing forward, with energy and vast improvement over his predecessors in the same race, the great work he had undertaken. The success he attained was perhaps unequalled, and his merits are admitted by all. His work on ichthyology was due to the joint labours of himself and Valniennes, its object being a *history*, *anatomy* and *classification* of fishes. Then we have Turton's 'British Fauna' in 1807; Donovan's 'Natural History of British Fishes,' 1808, a work which still holds a place in the estimation of naturalists; North's 'Fish and Fish Ponds'—no date, but evidently about this time, and Jenyns' very useful work appeared in 1835. In a summary of this description the name of Montagu cannot be omitted; he was an earnest worker, and a most successful one, and advanced our knowledge of marine zoology very much. In 1836 Yarrell's 'British Fishes' appeared. Mr. Yarrell's name will ever remain fresh and green, and will always hold an honourable place in the list of British authors. In 1840 Cope's 'Natural History' appeared; it is, however, a compilation from the works of previous writers. The name of Jonathan Couch will be remembered as that of an earnest, honest, painstaking naturalist; his 'Fishes of the British Isles' appeared in 1864–65. In the 'Report on the Herring Fisheries of Scotland,' 1878, Appendix No. 2, p 163, Mr. F. Buckland gives "Notes on the Natural History of the Herring." Nothing new, however, is brought out in these notes. Then follows 'The Herring,' by De Caux, in 1881. The name of Günther is now known over Europe and America in connection with the history of fishes. Few men have done more then he in that direction. And lastly comes the name of Dr. Francis Day. His work on

'The Fishes of Great Britain and Ireland,' in course of publication, must, when completed, hold first place over every other upon that subject.

Scotland has not done much to forward the cause of science in the line we are now considering. First, we have Sibald's, 'Scotia Illustrata,' &c., in 1684; Munro on the 'Structure of Fishes,' 1785; White's 'Observations upon the Present State of the Scotch Fisheries,' 1791; Edmondston's 'Views of Zetland,' 1809; and Low's 'Fauna Orcadensis' in 1813; Fraser's 'Review of the British Fisheries,' 1818; Fleming's 'Philosophy of Zoology,' 1822, followed by his 'British Animals' in 1828; Stark's 'Elements of Natural History,' 1828; Fraser's 'History of the Salmon and Herring,' 1833; and Parnell's 'Fishes of the Firth of Forth,' 1839; Shaw's 'Experimental Observations on the Development and Growth of Salmon Fry,' 1840—the most careful and reliable experiments yet carried out. The name of Dr. Johnston, of Berwick-upon-Tweed, cannot be overlooked, he having rendered valuable assistance to Mr. Yarrell. 'Fishes of Deeside;' 'Natural History of Deeside and Braemar,' by the late Professor MacGillivray, of Aberdeen University; Gordon's "Fishes found in the Moray Firth," in *Zoologist*, vol. x.; 'Some Fishes found at Peterhead,' Peach; 'British Association Report,' 1852, p. 78; Edward's "Fishes of Banffshire" in the *Naturalist*, vol. v.; 'The Herring,' by Mitchell, 1864; and 'The Salmon,' by Russell, 1865; Bertram's 'Harvest of the Sea,' 1865; Sim's "Catalogue of Fishes found in the Vicinity of Aberdeen," in the Transactions of Aberdeen Natural History Society, 1878.

Ireland has also done something towards the subject under consideration, those which may be specially noticed being Ruttly's 'Natural History of Dublin;' Smith's

'Natural and Civil History of Cork;' Smith's 'Natural and Civil History of Waterford;' also the different surveys of the various counties; and lastly, W. Thompson, of Belfast, who of himself did much to elucidate the fauna of that island; he also rendered much information to Mr. Yarrell. His name must ever be honourably placed in the annals of science.

Another name of world-wide reputation is that of the late Professor Sars, of Christiania, than whom few have done more in the work of extending our knowledge of marine zoology. Of recent works and articles on the subject of fishes which I have seen, is first, 'Die Harings Fischerei,' by Dr. Axel Wilhelm Ljungman, published at Stettin, 1880. This is a work wherein all influences, real and supposed, respecting the herring are considered, *excepting its food;* on this point almost nothing is said. In *Nature* for February 3rd, 1881, is an article on "Deep-sea Exploration," by J. Gwyn Jeffreys, the subject being "Food." Although this article (which is an able exposition of the importance of the subject on which he treats) has no direct bearing on the food of fishes, indirectly, however, it has a very strong one, because many of the creatures whose food he considers form in turn the food of fishes. Then in *Nature* for April 18th, 1881, there appears an article on "The Herring," by Professor Huxley. Although there are points in this paper open to dispute, still it is an article which every one who is interested in the subject should read and study. Again, in the *Zoologist* for June, 1882, p. 221, there is a capital article by Dr. F. Day on "The Severn Salmon: Whence it comes and Where it goes;" and in the same publication, by the same hand, there is at p. 235 an interesting little article on the "Food of Fishes;" and lastly, in the *Field* for May 6th, 1882, Dr. Day points out, in a most conclusive way, the importance of our being thoroughly acquainted with the food of fishes.

Now when we contemplate this vast array of authors, and the list is by no means complete, many of whom have left "their footprints on the sands of time" more deeply than others, we find that their labours were confined to cataloguing the number of species, forming systems, or examining the anatomy of the various forms which came under their notice. Much has been said on the elegance of shape, the number of fins and fin rays, as also the number of teeth. Much has also been written as to their quality as articles of food, and their medicinal virtues. The arrangement of the scales has also received much attention, and justly so, because it is by such external appearances we can link the present with that of past geological ages. When we consider the great diversity of shape, and the modifications in dentition, as also the various forms of stomach, &c., of fishes, it seems strange indeed that former writers did not think it necessary to enquire what was the cause or necessity for such difference of form, *i.e.* enquire into the nature of the food of each species, so as to see if by that means they could explain why the catfish, for example, has its mouth completely armed with hard, bony tuberculated plates and long teeth; or why the extraordinary development of head and mouth in the fishing-frog; or, again, the strong, gizzard-like form of the stomach of the mullets. Curious, and beautifully adapted as the mouths of each of these fishes are to their habits of lurking in ambush or pursuing their prey, none of our great pioneers in ichthyology seem to have been struck with such modifications, or to have given the subject of food other than the most casual, I may say, careless notice.

Perhaps, all things considered, it need be no great matter of wonder that our early authors did not enquire very particularly into what constituted the food of the creatures whose history they portrayed, they having found the whole subject of ichthyology in such a chaotic state; still, considering all the circumstances under which they laboured, they have, perhaps, done all that could have been expected of them. The same excuse, however, cannot be conceded to more recent writers, who in many cases have confined their attention to one particular species, and who appear to think that a minute description of its external appearance and a few suppositions as to its habits, include all that is required of them. Indeed, many of them seem to have had ideas similar to those of Edmondston in his 'View of the Zetland Islands,' where, at pp. 316, 317, he says: "The sea is more abundantly supplied, and myriads of unknown species reside on its shores and in its rocky caverns. But while some of them, as being objects of utility to man, are deserving of attention, the whole race, considered as animated beings, is unworthy of the labour and time which has been so lavishly spent upon them . . . It does not enlarge our views of existence, and seldom adds to our knowledge of the principles of organic life." Few will homologate such principles nowadays, and when we call to mind the practice which used to prevail amongst those who could afford it, of having fish-ponds, and the great expense some went to in having such ponds prepared and stocked with fish, it does seem a matter of wonder that no more attention was given to the food of fishes generally, and particularly that of such species as are likely to live in those ponds. One would think that a desire for change, i.e. a greater variety of fish, would have induced some one to enquire into the subject of food. But such does not seem to have been the case, and pond-owners were content to have a few carp, &c., which they thought were sufficiently cared for if a few handfuls of oats were occasionally cast into the pond, while others considered themselves more "knowing" when, before putting the oats into the water, they had it steeped for a time in ale.

The time has now come, however, when, in natural science, we

> "Think nought a trifle, though it small appear;
> Small sands the mountain, moments make the year,
> And trifles life."

The point, then, we have under review is one which has not received the attention it merits. This is the more to be regretted in reference to our own country; for what nation is there whose prosperity depends more on its fisheries than our own? As already said, the subject of the food of fishes has not been thought of sufficient importance, or rather, its importance has not been understood by us as a nation, and we are only now awakening to the sense of our neglect. True, some little notice has been taken of the subject by most writers, and recently several papers have appeared upon the subject which will be noticed in their proper place. The subject is one of vital importance to Britain, and one which will require many years' study to elucidate. However, considering the short time that has elapsed since the announcement was made that a prize would be given by the promoters of the London Fisheries Exhibition, for an essay on the subject, it can hardly be expected that sufficient work could be done within that period to set the question at rest. That would be an

[illegible]

[illegible] It is not to be understood that [illegible] has been written by others [illegible] where such [illegible] however [illegible] copy from [illegible] away pleasantly [illegible] in many cases [illegible] what they mean [illegible] introduction: 'The [illegible] to examine and describe [illegible] the trouble of each investigation [illegible] the nature of the materials which he has obtained [illegible].' I assume therefore, for it is not stated, that [illegible] the result of each analysis [illegible] and on these lines are the following remarks recorded.

The question has often been asked, "What benefits are expected to accrue from a thorough knowledge of the food of fishes?" One answer amongst many others that could be adduced will suffice. Now that the acclimatisation of different species of fish is considered necessary and desirable, the fact of our knowing the food of each species will enable us to judge, almost to a certainty, whether the fish intended to be dealt with can or cannot live in the quarters assigned to it, because, by a little dredging and other observation on the ground selected, it can be told exactly whether the food required by the fish be there or not, and if absent we can also tell whether, if brought [illegible] it will thrive as well, for most of the food of fishes consists of some form of animal life. This surely is of itself sufficient to warrant our becoming acquainted with the food of each species.

Speaking generally, most fishes live upon the same sort of food, but speaking from analogy we should naturally conclude from examination of their internal structure that their food must be very different; but analogical reasoning cannot be always relied on, and in the case of fish it is particularly unsafe. To illustrate my meaning let us look at the internal arrangement of birds, and we at once see the vast difference which exists in the various tribes of that class of beings. By such examination we can reason pretty accurately what is the nature of their food, even though we may be otherwise ignorant of it. As an example let us look at the viscera of an eagle, and we find a very short intestine and but the rudiments of cæca; in this we have the true characteristics of a bird of prey. Turning to the same organs in the pheasant or grouse, we find a very long intestine, as also long cæcal appendages, the characteristics of grain- or herb-eating birds. These, we may say, are the two extremes, and the various other forms converge towards these two centres. Now although in fishes differences quite as great exist, still we cannot say that we have in one case an animal of prey or flesh-eating fish, nor on the other that we have a grain or herbivorous fish. No. On the one side we have the cod with its long intestine and numerous cæcal appendages, and upon the other we have the sharks, sturgeon, skate, and rays, with short intestine and no cæcal appendages. Looking at these modifications in structure superficially, we would conclude that in the sharks, &c., we had an analogue of the eagle, and in the cod, &c., that of the pheasant and grouse; but looking a little more closely at the shark tribe we find a beautiful spiral arrangement in the intestine which presents quite as great a surface for absorption, &c., as that of the cod, the want of the cæca and shortening of the bowels notwithstanding. Suppose we take into account the formation of the mouth, &c., of birds and fishes; we can arrive at no other conclusion than that while the beak and feet of birds will lead us to the same result as that reached in the examination of the internal arrangements, it is not so in the case of fishes, for while we find modifications in the form of mouth and dentition exhibiting even greater diversity of form than in the case of birds, we cannot by such appearances arrive at a just conclusion as to what they feed upon. This, however, has often and often been done; hence the many errors that have been handed down from one writer to another. As will be seen from what follows, although the food differs in species, still the cod is as much a fish of prey as the shark; it is therefore an absolute necessity that we open the stomach of each species and examine its contents. In no other way can we speak with certainty as to what the food may be. When this question has been definitely settled, the introduction of some species of sea fish into fresh water will not be so difficult as it at present appears, nor do I think that the difficulty of introducing a considerable part at least of their natural food, along with the fish themselves, will be insurmountable, because I find that many of the smaller crustacea, especially those of the genus *Mysis* can be seen disporting themselves in endless numbers in brackish water, and these, no doubt, could with care and gradual stages be made to accommodate themselves to water entirely fresh. Now as these form part of the food of various fishes, and as it has been affirmed that cod, plaice, flounder, and other sea fishes have been known to thrive in fresh water, if these creatures can be introduced into inland waters, especially near large seats of population, what an immense advantage would it prove in such localities. I say, if this can be done, by all means let us make ourselves thoroughly acquainted with the food of fishes, for this is the first step toward the desired and now necessary improvement.

"The food of fishes," says Mr. Yarrell, page 19 of his introduction, "is very different at different periods of the year, and this may be one of the causes, among others, of the particular excellence of the flesh of some species of fishes at particular seasons." That fishes have their seasons of excellence is undoubted, but that this superiority is caused by a difference of food is very doubtful; indeed I do not think it is so to any appreciable extent; that is, of course, always assuming that they are obtaining a sufficient supply. Short commons will soon make a difference upon them, as it will on any creature. But why should we look for a change of food as the cause of the difference in quality in this class of beings when we see such a different state of things prevail among land animals? We find that they have their periods of prime condition, although the food be exactly the same all through. A few familiar instances will suffice to explain my meaning. Take deer amongst quadrupeds: they at certain seasons are almost uneatable; and again the goat, rather an extreme example, how strong and repulsive is the odour which exhales from him at particular seasons, although the food of both deer and goat is pretty much alike all through the year. Then, again, take pheasant, grouse, and partridge, who all have their seasons of excellence, and yet there is no great change in the food. Of course, as already hinted, a short or abundant supply has its effect upon them, and all other animals. I therefore think that the primary object in the life of these creatures, i.e. procreation, has more to do with condition than that of food. Although it is admitted that food has its influence on such birds, for instance, as live by the sea in winter, and upon the hills during summer, their quality as articles of food is very different at these times, so it is with pheasant, grouse, and partridge, if they are driven to take sustenance from a food which does not agree with them. But then let us take the cod as an example among fishes. There is no season, so far as I am aware, in which one particular sort of food predominates over other kinds, yet this species, like others, has its periods of good and bad condition. Then, again, in the case of the herring, take for example those caught along the north-east coast of Scotland during the months of January, February, and March, and compare them with those caught in Loch Fyne in July and August. Nothing could be more marked than the difference between the two; those of the east coast being large, coarse-fibred, dry, free from fat, and tasteless; while those of Loch Fyne are also large, but fat, sweet-tasted, and of free, fine-grained fibre, almost melting in one's mouth; and yet I can assert from observations personally made at both localities that the food is almost identical. Then how comes the difference? It is from the fact that the east coast fish are full of milt and roe, which they are about to deposit, and the food they have been eating for some time has gone to bring such milt and roe to maturity, leaving nothing more for the body than keeps it in working order, if I may so speak. On the other hand, the west coast fish, as already said, are, on an average, of larger size than the east coast ones, but at the period alluded to they have neither milt nor roe except in a rudimentary condition, consequently all the nourishment from the food goes to make the body what it is. In the one case we may liken the one sort to that of cattle that have been for a time under the farmer's particular care, so as to render them fit for market; and the other, to oxen with which he has been tilling his land, or cows he has allowed to give suck to their young. These Loch Fyne fish have enjoyed a reputation for excellence over others which seems to me to have been overstrained, and the reason of this supposed superiority has been attributed to a different sort of food, which is an error. In the first place, if we take an east coast "mattie," which is a fish in the same condition as those of Loch Fyne, cook it in the same way as Loch Fynes are cooked, that is, simply boiled while quite fresh, and I think it will take a person of extremely fine taste to detect a difference. The reason, then, that Loch Fynes have got their good name is because they are all of one quality, while east coast fish are mixed quality, i.e. "matties and fulls" together; and, again, the food is in greater abundance in Loch Fyne than on the east coast. While prosecuting my investigations at Loch Fyne, I was frequently told that the cause of the excellence of the fish was because of the abundance of food that was washed from the hill-sides into the loch; and I find that J. G. Bertram, in his 'Harvest of the Sea,' page 28, gives a similar account.

At page 16 of his introduction, Mr. Yarrell says, "It is a rule, almost without an exception that I am aware of, that those fishes provided with barbuls or cirri about the mouth, obtain their food near the ground; and these feelers, as they are popularly called, appear also to be a valuable compensation to those species which, restricted by instinctive habits to feeding near the bottom of water that is often both turbid and deep, must experience more or less imperfect vision there from the deficiency of light." I cannot see that this holds good as a rule; indeed there seems to be no such rule either for or against, and from what Mr. Yarrell says about flat fish seems to go quite against the view above quoted, because we find none of our British flat fish possessed of said organs, and still he says they are ground feeders; while, on the other hand, we have cod, ling, torsk, &c., possessed of these appendages, yet none of them can be called ground feeders, especially so in the case of the ling.

Again he remarks at page 14 of introduction: "Those fish that live near the bottom of the water have a low standard of respiration, a high degree of muscular irritability, and less necessity for oxygen;" and instances carp, tench, eels, and skate as examples. Also that "they sustain life long after they are taken out of the water, and their flesh remains good for several days." This is a generally received opinion, and is no doubt in part correct, but I think some further explanation is needed than the mere fact of their requiring less oxygen; hence, as he says, their remaining fresh longer. What leads me to this mode of thinking is the fact, that I find haddocks, which are looked upon by Mr. Yarrell as "midwater fish," to be actually as much a ground feeder as any flat fish we have; still we do not find haddock to keep so long as flat fish; and, further, seeing that haddock do find their food at the bottom, if Mr. Yarrell's argument were the right one, might we not reasonably expect some modifications in structure, or some adaptation of parts for such a mode of life? Still we find no difference between this species and that of its near relative, the whiting, and yet the former might be likened to a pig rutting in the muddy bottom, while the latter might with equal propriety be likened to some of the hawk tribe, pursuing its prey through the air.

It has been said, "Science from its nature is every hour advancing; but the greater writers will not remain the less immortal," and without doubt many of the names already mentioned will remain immortal; while we may assume that all have done the best they could, and have been actuated by a desire, as Pliny says, "to transmit to posterity some memorial that they have at least lived." It has therefore been left for the present generation to make its mark in the march of science by bringing the subject we are considering to a successful termination.

In the following pages I have thought it right to make quotations from authors in order to show the present state of our knowledge of this subject, giving after them my own observations.

In following out my desire to know what constitutes the food of fishes, I have endeavoured to go a step further, that is, to learn as far as possible what is the food of the food of fishes. Thus the cod feeds upon haddock, whiting, and various fishes, &c.; so in turn the food of these species has also engaged my attention, and the following has been the result.

THE FATHERLASHER; "Gunplucker." *Cottus bubulis* and variety *Grœnlandicus* (Yarrell).

"Its food is small crustaceous animals, and is said to be particularly partial to feeding on the fry of the blennies" (Yarrell).

"Lives on small sucking fish (*Liparis, &c.*), shrimps and *Terebellæ*, fragments of green algæ" (McIntosh; Day's Fishes).

"It devours small crustaceous animals and any other creature it is able to swallow" (Couch).

What I have found in the stomach of this species are anemones, *Grammarus marinus*, *Idotea tricuspida*, young of *Carcinus mænas*, small specimens of spotted gunnell (*Centronotus gunnellus*), *Crangon vulgaris*, fragments of sessile-eyed crustacea, *Pycnogonum littorale*, young brachyurous *Decapoda*, various forms of sessile-eyed crustacea which I have been unable to identify specifically, and small specimens of the common mussel.

COMMON GREY GURNARD; "Gowdie." *Trigla gurnardus* (Linn.).

"They devour shell-fish, crabs and small fish" (Couch).

Mysis spiritus, also a species of the *Mysidæ* not described by Bell, and which I have named provisionally. *Themisto Dickieana*, these were in great numbers in the stomachs during the month of July. Some specimens of what appears to be a goby, but too much digested to identify specifically. These creatures had in turn been feeding on the *Mysidæ* above mentioned. *Pandulus annulicornis*, *Crangon vulgaris*, larval forms of the genera *Paguridæ* and *Astacidæ*, sand-eels, *Mysis chamæleon*, and fragments of fish.

THE ARMED BULL-HEAD; "Miller's Thumb." *Agonus cataphractus* (Günther).

"It feeds on aquatic insects and small crustaceous animals" (Yarrell).

"Feeds on worms and small crustaceous animals" (Couch).

"Its food consists of aquatic insects, worms and small crustacea" (Day).

Crangon vulgaris, small individuals of *Carcinus mænas*, *Atylus Swammerdamii*, *Corphium Ronellii*, are what I have found, but I have not seen beyond a dozen of this fish since beginning the inquiry.

THE FISHING FROG; "Cathie." *Lophius piscatorius* (Linn.).

Yarrell, Couch, and Day give each an interesting account of the voracity of this species, but all too long for insertion here; I shall therefore confine myself to personal observation. One of this species, itself only fourteen inches long, had a whiting of ten inches in its stomach, haddocks, and herring. From the stomach of one I took one plaice twenty-four inches long, another nineteen, and one fourteen and a half inches respectively, as also four cod from one to two feet long. The tail of the plaice was protruding from the throat, and of these fishes none had the slightest mark of injury. On one occasion I found a large fishing frog in a pool left by the tide, and, wishing to see something of its movements, I took the sole of an old boot which I found at hand and made it skim along the surface of the water in the direction of the fish, which it at once snapped at and caught as a dog would a piece of bread; several other articles I threw at it, which it caught in the same way, but never moved from the place it first occupied.

THE MACKEREL; "Rannach" of the Loch Fyne district.
Scomber scomber (Donovan).

"Their principal food is probably the fry of other fishes" (Yarrell).

"Their food is still a subject in which much remains to be investigated. Doubtless they prey among members of the herring family and the fry of such forms as come in the way" (Day).

This is not what can be called an abundant species on the north-east coast of Scotland. In some I have found a granular fatty matter, in others fragments of fish, annelids, mud and herrring fry, which in turn had their stomachs filled with *Copepoda*, mostly *Temora longicornis*. In July last their stomachs were sometimes crammed with sand-eels, *Ammodytes tobianus*. On the west coast, however, they are much more abundant, and their food in that quarter consists (July 28th 1882) of *Thysanopoda Dayii* (this name I have given to this species provisionally) and herring scales; July 26th, herring scales and remains of *Copepoda*; July 27th, 28th, and 29th, *Thysanopoda Couchii*, "*Suuldku*," i.e. black-eye of the fisherman, small *Clupeidæ*, and very large numbers of the *Copepoda*, principally *Temora longicornis*, the "*Croyerg*," or, for shortness, "*Croy*" of the fishers. In the early part of the season they literally swarm in Loch Fyne, as the fishermen tell me, giving the water, as they say, a blood-red appearance. I have found them abundant in the pools at low tide in July. From thirty to forty of the fish were examined on each of the above-mentioned dates. It would be premature to say at present what is their chief article of food.

THE SCAD OR HORSE MACKEREL. *Carnax trachurus* (Lacép.).

They "pursue the fry of herring, sand-launce or other favourite food" (Yarrell).

"They are great enemies to pilchards, the herring fry and the sand-launce, &c." (Day).

This cannot be called an abundant species along the north-east coast of Scotland, although they are occasionally brought in by line-fishers and also by trawlers. *Mysis spiritus*, *Crangon vulgaris*, scales of fish, and a flesh substance which was unrecognisable, is all I have seen in their stomachs. This fish is a poor article of food.

JOHN DORY. *Zeus faber.*

"The food of the dory is the fry of other fishes, molluscous animals and shrimps" (Yarrell).

From the stomach of one Couch took twenty-five flounders, three half-grown father-lashers, and five stones. One which weighed 1 lb. 1 ounce was found to contain eighteen sprats, two sand-smelts, and one cuttle-fish, besides a number of small fish in a decomposed state (Day).

This is a scarce species in my locality, and only three have turned up during the time my observations have been carried on; in them were found fragments of haddocks and whitings and *Pandalus annulicornis.*

THE FRECKLED GOBY; "Donlie." *Gobius minutus* (Don.).

"Its food consists of small crustacea" (Day).

I have found in its stomach fragments of stalk-eyed crustacea; some of the *Mysidæ*, the posterior half of *Mysis spiritus*, frequently turn up.

THE GEMMEOUS DRAGONET; "Balle'erie;" "The Blue Devil" of the Argyle coast. *Callionymus lyra* (Linn.).

"Its food is testaceous animals, molluscous animals, and worms" (Yarrell).

"It feeds on crustacean animals, which it swallows entire, as on worms and mollusca" (Day).

Couch remarks, "The food is [illegible] a considerable portion of the crustacea," [illegible]. He also says, "Nor does the species now mentioned so frequently take a bait." This is an error, as during the summer months I often find them to have swallowed the bait on the fishermen's lines, and are thus brought to land. Their food consists, so far as I have observed, of [illegible] *Portunus* [illegible] *Pleurotoma turricula*, and fragments of *Ophiuridæ*, and small specimens of *Echinus sphæra*.

THE LUMP-SUCKER, "Paddle-cock," the "Kerk-[illegible]," i.e. Sea-hen of the Loch Fyne district. *Cyclopterus lumpus.*

"Feeds principally on young fish, of which it devours a large quantity" (Yarrell).

"Crustacean animals (*Onisci*) have been found in their stomachs; and from the great length of the entrails, it may be judged that a portion of its subsistence, at least, is derived from sea vegetables" (Couch). As I have endeavoured to show, this is a very doubtful judgment to go by.

"Its food consists of marine worms and small fish, while crustaceous animals as *Onisci* have been found in its stomach" (Day).

In its stomach I have found *Hypera Galba*, Herring fry, *Idotea tricuspidata*, *Gammarus marinus*, and another species of sessile-eyed crustacea not known, annelids, sand-eels, and, during February and March, large masses of white fleshy matter not known.*

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* April 21st.—By the examination of twenty-four more examples of

In the pools left by the tides between Ardrishaig and Lochgilphead, Argyleshire, I found large numbers of this species, of from half an inch to one inch in length, some of a dark, almost black colour, which are there called "Bodachgrasies;" others of a bright orange colour—these get the name of hen-fish.

THE SPOTTED GUNNEL, or Butterfish. *Centronotus gunnellus* (Günther).

"Its food is marine insects, the spawn of other fish and their fry" (Yarrell).

"Its food appears to be for the most part of the smaller crustaceous animals" (Couch).

"Its food includes *Hippolyte*, sessile-eyed crustacea, annelids, starfishes, and small mollusca" (McIntosh).

"It consumes marine insects, and is said to be very destructive to the eggs and fry of other fishes" (Day).

Idotea tricuspidata, young specimens of *Carcinus mœnas*, *Gammarus marinus*, minute examples of various shells, small worms, and barnacles are what I have observed.

THE HERRING; "Scattan." *Culpea harengus* (Linn.).

"It seems certain that it feeds on *Entomostracæ* and the young or smaller crustaceans, but it also devours creatures of a larger size, since young fishes of several sorts, with the

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the lumpsucker, I have been able to determine that the white fleshy matter alluded to is the remains of cuttle-fish. I find, also, that *Medusæ* are largely eaten. These fish appear "inshore" about the beginning of January, and disappear about the end of April; within that time the spawn is deposited.

smaller lances of the length of a couple of inches, have been found in their stomach, and even the grains of roe and young examples of their own species" (Couch).

"I have often found the young of the whitebait, with small shrimps, in the stomach of herring" (Parnell).

"The food of the herring consists (according to Dr. Knox) of minute *Entomostracæ;* when near the shore they add to these the young of their own species, the spawn and fry of other kinds of fishes, small *medusæ* and crustacea" (Hamilton).

"What their food is near the pole we are not yet informed; but in our own seas they feed much on the *Oniscus marinus* and crustaceous insects, and sometimes on their own fry" (Pennant).

The herrings "subsist on the smaller *cancri*, *medusæ*, and animalcules" (Scoresby).

"The herring feeds largely on the sea caterpillar" (Rondeletius).

The food of the herring is "chiefly small crustacea, and for their existence and abundance other still smaller organisms must be present" (Ljungman, 'Die Härings-Fischerei,' p. 46).

"In all the herrings I have opened, amounting to a very considerable number, I have found more or less distinct remains of *Entomostraca* and other crustacea" (W. von Wright).

"On February 15th of this year, 1882, I investigated the contents of some herrings' stomachs sent me from Mevagissey in Cornwall, by Mr. Dunn; they contained the remains of small crustacea, ... sand-launces, ... that excessively rare British goby, *Crystallogobius Nillsoni*, ... mackerel midges, *Motella*" ('Notes on the Line and Herring Fisheries of the North-east of Scotland,' by Francis Day).

Mitchell, in his 'History of the Herring,' says, at pp. 48 and 49, he found on several occasions sand-eels in their stomach; and at p. 6 of his preface to that work he remarks: "The author believes he has satisfactorily solved the hitherto disputed questions as to food, periodical visits, migrations, &c." Something, however, has been done in the same direction since he wrote, and much yet remains to be accomplished.

The following is the result of my observations which in this particular species has extended over nearly five years. On the east coast 616 herrings have passed through my hands, and at Loch Fyne about 400 more. On the east coast their bill of fare is, of crustacea, small brachyurous *Decapoda*, *Thysanessa borealis*, *T. Aberdonensis*, *Mysis spiritus*, *Thysanopoda Couchii*, small specimens of the genus *Galathea*, *Acanthocaris Livingstoneana*, *Lestrygonus spinidorsalis*, *Hyperia Galba;* during February of the present year (1883) the stomachs were quite full of the latter. Of the *Copepoda*, *Cytherė minna*, *C. acuta*, *Temora longicornis*, *Evadine Nordmanni.* Very small univalve mollusca, flies, beetles, *Sagitta bipunctata* (?), bits of cuttlefish skin, herring fry, scales and spawn, sprats. On Loch Fyne *Thysanopoda Couchii*, *T. Dayii*, which the fishermen call "Suuldhu," i.e. black-eye. The *Copepoda*, "Croy," is also devoured in vast quantities, principally *Temora longicornis.* Chief food: *Sagitta bipunctata*, *Mysis spiritus*, *Hypera Galba*, the *Copepoda*, young *Clupeidæ.*

THE SPRAT; "Garvie." *Clupea sprattus* (Linn.).

"Sprats spawn in March, and their food is similar to that of the herring" (Hamilton).

"Feeds on small crustaceous animals" (Parnell).

Yarrell and Couch are silent as to the food of this species. So far as my observation has extended, the food consists of the *Copepoda*, *Mysis spiritus*, *Themisto Dickieana*, and *Hyperia Galba*. It is a curious fact that in almost every instance where *Mysis spiritus* is found in the stomach of fishes, *Themisto Dickieana* is also present.

THE SHAD; "Rock Herring."

"The food of the shads is small fish and the softer-skinned crustacea" (Yarrell).

"The food of the Twite shad consists chiefly of the small crustacea" (Hamilton).

"The principal food of the shad seems to be small fishes, such as sprats, whitebait, and young of the herring" (Parnell).

This species is not an abundant one on the north-east coast of Scotland, its food in the few I have seen being herrings and sprats, *Mysis spiritus*—these sometimes in hundreds—and *Themisto Dickieana*.

THE COD. *Gadus morrhua* (Linn.).

"Feeds near the ground, on various small fish, worms, crustacea and testacea" (Yarrell).

Mr. Couch gives a long list of food found in the stomach of this species, and Dr. Day a still more extended one, both too long for insertion in this paper.

"The food of the cod is either small fish, worms or crustaceous animals, such as crabs, large whelks, &c." (Pennant).

Fleming says nothing as to the food of fishes beyond such as are kept in ponds, and even these he does not name.

The food, he says, "should consist of any kind of corn boiled or steeped in water for some time until it swells. Malt is esteemed a very fattening food, and the crumbs of bread steeped in ale; but peas are considered as little inferior to either."

"Feeds on worms, crustacea, shell-fish, &c." (Jenyns).

"The cod-fish is very voracious, devours everything eatable" (Low).

"Small fish of all kinds, mollusca, worms, and crustacea; among the latter crabs of considerable size are found in their capacious stomachs" (Hamilton).

"Small fishes, crabs and worms of various kinds are the chief food of the cod" (Cope).

"This animal's chief place of resort is on the banks of Newfoundland. Hither the cod annually repairs in numbers to feed on the quantity of worms that are to be found there in the sandy bottom, and when their provision there is exhausted, or the season for propagation returns, they go off to the Polar seas, where they deposit their spawn" (Buffon).

"Lives on the smaller fish, *Sepias*, crustaceans, in fact anything that comes across their voracity" (Wraxall).

Many other quotations might be given, but it is unnecessary, as they are almost all alike, and seem to have been copied from one another.

The number of fish examined, 372, the stomachs containing of true fishes, haddock, whiting, plaice, flat fish, generally unrecognisable specifically; lemon sole, viviparous blenny, which in turn I have found had often sessile-eyed crustacea in their stomach, generally the *Gammaridæ*, sand-lance, sand-eels. During the months of January and February the latter were all in full milt and roe; young of the *Clupeidæ;* fishing-frog, [illegible] twenty [illegible] the [illegible]

In examining the stomach of this species care must be taken that mollusca do not get too prominent a place in the list of articles found, because many of the univalve shells found there have often, when swallowed, been tenanted by hermit crabs. Stones, again, are often in their stomachs and these I have frequently found to have anemones attached to them; hence the reason of their being swallowed Old shells are often taken up under the same condition. Chief articles of food, haddock, whiting, herring, *Aphrodita aculeata*, and cuttle-fish; *Hyas coarctatus*, *Atelecyclus heterodon*, and *Pagurus Bernhardus*.

THE HADDOCK. *Gadus æglefinus* (Linn.).

"During the summer they live on young herrings and other small fish, in the winter on the stone-cotted worms (*Sepula*). They consume great quantities of herring ova and fry, while the sprat is likewise favourite food" (Day).

"In summer they live on young herrings and other small fish, in winter on stone-cotted worms, a species of *Serpula*" (Pennant).

"Their food is small fish, and almost any of the inferior animals of the deep, even the spiny *Aphrodita*" (Yarrell).

"It feeds principally on crustacea" (Parnell).

"Feeds near or from the ground, and uses little discrimination in the choice. In a single stomach, among a multitude of univalve and bivalve shells, I was able to select no less than twelve separate species" (Couch).

The following is my catalogue of its bill of fare, as seen in 472 individuals examined.

FISH: Its own young, whitings, herring fry; in the month of December these were in great abundance. Small flat fish, invariably too much digested for specific identification;

these were also at times in great numbers; goby. In addition to the above, bits of fish were often present which it was impossible to identify.

CRUSTACEA: *Carcinus mænas*, *Portunus holsatus*, *Pagurus Bernhardus*, *P. lævis*, *Galathea Andrewsii*, *Diastylus* (?), small form of these in thousands; *Crangon vulgaris*, *Pandalus annulicornis*, *Thysanopoda Dayii*, *Mysis chamæleon*, *M. spiritus*, *Themisto Dickieana*, *Annonyx denticulatus*, *Bathyporeia* (?), *Phocas* (?), *Arcturus gracilis*, *Arcturus longicornis*, *Idotea linearis*, in numbers; *Gammarus marinus*, *Atylus Swammerdamii*.

MOLLUSCA: *Turnatella fasciata*, *Tellina Fabula*, *T. tenuis*, *T. pusilla*, *Nucula nitida*, *Solen pellucidus*, *S. siliqua*, this species is largely eaten. *Scrobicularia prismatica*, *Natica Alderii*, *N. Montacuti* (?), *Scaphander lignarus*, *Fusus antiquus*, *Mactra stultorum*, *Astarte sulcata*, *Caraium edule*, *C. echinatum*, *Donax anatinus*, *Venus lincta*, *Mya arenaria*, *Psammobia Ferroensis*, *Leda minuta*, *Odostomia rufa*, *Cylichna cylindracea*, *Buccinum undatum*, *Cyprina Islandica*, cuttle-fish.

STAR-FISH: *Ophicoma brachiata*, *Opherina texturata*.

ECHINIDÆ: *Echinus sphæra*, *Echinocyamus pusillus* *Amphidotus cordatus*. *Holothuria*, not known (see specimen in bottle No. 61); anemone, *Aphrodita aculeata*, annelids, this includes those with and without sand-cases. Bits of coal cinder, spawn, doubtless that of *Amphidotus cordatus*. A small moth. Round black bodies, probably small forms of *Holothuria*, twigs of wood, grass, bits of lucifer matches, bits of sea-weed, sand. Chief articles of food, *Ophiocoma brachiata*, *Ophiura texturata*, *Amphidotus cordatus*, *Tellina Fabula*. Indeed, during the month of June these were almost the only food, with the exception of a very few sand-eels towards the end of the time, and during that month ninety-eight fish were examined. Of course this statement may be of no value, as perhaps such may not occur again; still, from the end of that time fish became more common, and continued through the winter. I have taken twenty-six sand-eels from one stomach.*

THE BIB. *Gadus luscus* (Linn.).

Not an abundant species in my locality, and never attains a large size. "Thomson mentions finding crabs (*Brachyuri*) and a *Trochus tumidus* in the stomach of one which he opened; while another contained fish remains; it also eats worms" (Day).

"Its chief resort is in rocky places, where it finds its congenial food in the multitudes of crustaceous animals and small fish which frequent such neighbourhoods" (Couch).

"Its food is small fish and the various animals allied to the shrimp" (Yarrell).

Two individuals are all that have come under my observation since June last. Their stomachs contained *Pandalus annulicornis*, *Hyas coarctatus*, *Hippolyte producta* (?), and one sessile-eyed crab. On the north-east coast of Scotland it is not held in great estimation as an article of food; it is, however, very good.

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* April 20th.—Since the foregoing was written, I have also found *Galathea nexa*, *Hyas coarctatus*, *Callianassa subterranea*, and *Sertularia abietina*, in the haddock's stomach.

THE POOR COD; "Skelchie." *Gadus minuta* (Linn.).

"They live on small crustaceous animals" (Day).

"Their food is the small crustacean animals" (Couch).

Yarrell says nothing as to the food of this species. Parnell does not name it as a fish of the Firth of Forth; and Hamilton remarks, "We have not seen any Scottish locality assigned to it."

On the north-east coast of Scotland it is not an abundant species, occasionally brought in by line-fishers during the summer months, as also by trawlers in winter; it is of little value as an article of food. Seventeen examined, and their stomachs contained sprats, sand-eels, vertebræ of some small fish; *Crangon vulgaris, C. spinonus, Pagurus Bernhardus, P. lævis, Mysis spiritus, Hippolyte pandaliformis, Hippolyte* (?), *H. varians, Galathea Andrewsii, Cirolana Cranchii*, and one sessile-eyed crab. This species is very good eating, but being small, never commands a high price.

THE WHITING; "Fitten," Scotland. *Gadus merlangus* (Linn.).

"Seizes indiscriminately any of the mollusca, worms, small crustacea, and young fishes" (Yarrell).

"Its principal food is the fry of other fishes, but mollusca, crustaceous and other marine animals of small size are likewise devoured" (Hamilton).

"Their food is principally mollusca and crustacea" (Parnell).

"When the young of several sorts abound, as they do especially towards the end of summer and autumn, whitings are busily eager in following them in their movements. From the stomach of a whiting that weighed 4 lbs. were taken four full-grown pilchards" (Couch).

"Subsisting on small fish, crustacea, and any animal substance it can obtain" (Day).

Number examined by the writer, 299. Of fishes, there were sand-eels most abundant during July; *Gobius minutus;* herring fry in greatest numbers during August and September; their own young, who in turn had their stomachs filled, especially during August, with young brachyurous *Decapoda.* I have also found them with full-grown herring, part of which was sticking in the throat quite fresh, while the portion in the stomach was much digested; sprats; during the latter half of September, and through October, their own young was their chief, indeed almost their only food. I have frequently taken six to eight from one stomach, each being from four to six inches long, and in every case these young had been swallowed tail first, showing conclusively that it had been all through this time a case of the old pursuing the shoals of young.

CRUSTACEA: *Portunus holsatus, Diasdylus* (?), *Crangon vulgaris, Pandalus annulicornis, Mysis spiritus,* and *Themisto Dickieana;* during August and September these were in hundreds; young brachyurous *Decapoda, Amathilla Sabini, Iphimedia obesa, Lysinassa Atlantica, Anonyx denticulatus, Atylus Swammerdamii, Gammarus marinus, Hyperia Galba* —many of these during the month of December—and two species of sessile-eyed crustaceans which I have been unable to identify.

MOLLUSCA: *Scrobicularia prismatica, Nucula nitida, Tellina Fabula, Buccinum undatum.* On several occasions mollusca denuded of their shells were in the stomachs, which it was impossible to identify. Cuttle-fish—these mollusca were not in great numbers at any time, nor were worms present except on one occasion. *Tublaria indivisa* in large quantities during the month of October.

Echinocyamus pusillus, Aphidotes cordatus, Ophiura texturata, Ophiocoma brachiata—none of these were in quantity. In August minute roe was often present, which I think may have been that of the *Mysidæ*, also fragments of seaweed. The chief food of the whiting is, therefore, its own young, sand-eels and herring fry, as also full-grown herrings.

THE COAL-FISH; "Colmines." *Gadus verus* (Linn.).

Mr. Yarrell is mute regarding the food of this species. Mr. Couch says, "It is eminently a ravenous fish," but goes no further. Dr. Day remarks, "Thomson mentions finding principally small crustaceans, as *Idotea*, &c., in the stomach of these fishes. Dr. Drummond usually observed that they were gorged with *Onisci*, and very fond of *Entomostraca*. Mr. Fennel saw twenty-six salmon fry taken from the stomach of these fishes."* My observations have been as follows:—

FISHES: Haddock, whiting, sand-eels, salmon smolts, herring, young cod.

CRUSTACEA: *Portunus holsatus, Nephrops Norvegicus, Idotea tricuspidata, Amathilla Sabini, Gammarus marinus, Atylus Swammerdamii*, annelides, small stones; and on July the 7th a clasp-knife, with the blade open, which along with the handle was seven and a half inches long, was taken from the stomach of one of these species.

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* April 23rd.—*Asterias rubens* and *Galathea squamifera* have been noted in the stomach of coal-fish since the foregoing was written.

THE LING. *Molva vulgaris* (Fleming).

"Of most voracious appetite, feeding on young fish, not sparing anything that has life" (Yarrell).

"The ling is an eager feeder, and yet it displays some degree of choice in the selection of its food, among which a living prey is preferred, although it will readily swallow a piece of herring, pilchard or a slice or two of three kinds of cuttle. Lacépède remarks that this fish shows a decided preference for the plaice. . . . From one ling seven of the last-named species, which varied in length from six to ten inches, have been taken. Skulpins also are sometimes found, and even a rough-hound of considerable size" (Couch).

"May be said to devour every kind of marine animal that falls in its way" (Hamilton).

"One was captured some years since off Breman Head, county Kerry, inside of which was a pewter flask containing two glasses of ardent spirit." In another was "found a three-gill bottle, some herrings, and a codling. There were also several pieces of parchment and bits of sealing wax" (Day).

My finds have been, of fishes: Herrings, cod, haddock, sand-eels. Large pieces of fish often occurred which it was impossible to identify.

CRUSTACEA: *Portunus holsatus, Crangon vulgaris,* and one sessile-eyed crustacean; fragments of shell, and a sea-gull, *Rissa tridactyla.* The chief food of this species is undoubtedly fish.

THE SAND-EEL; "San'ils." *Ammodytes tobianus* (Linn.). (*Ammodytes lancea* of Yarrell, &c.)

"The food is marine worms and very small fish" (Yarrell).

This is an abundant species on the Aberdeenshire coast, and in summer is largely used as bait for other fishes, during which time it comes close inshore, and its only food through that time, so far as my observation extends, is the *Copepoda*, especially *Timora longicornis*.

THE SAND-LANCE; "Ornals." *Ammodytes lanceolatus* (Günther).

(*Tobianus* of Yarrell.)

This species keeps to deeper water than the preceding, and my only mode of finding it is in the stomach of cod. It attains a length of from twelve to fourteen inches; its food is young herrings.

THE LONG ROUGH DAB; "Bastard Sattie." *Hippoglossoides limandoides* (Day).

First recorded as British by Parnell in the 'Edinburgh New Philosophical Journal' for July 1835, and he found in their stomachs what seemed "to be broken fragments of some species of *Asterias*." His largest specimen measured fifteen inches in length. "Cock's specimen had its stomach filled with the shells of *Turritella terebra*, two-thirds of which contained crabs, *Pagurus*" (Day).

This species is frequently caught at Aberdeen by line-fishers during summer. Now that steam trawlers have commenced operations there, dozens of these fish are brought to land every time the trawlers go to sea. The largest I have seen measured twelve inches in length. Number examined, 41. Their food consists of, first:

FISH: Grey gurnard, *Gobius minutus.*

CRUSTACEA: *Portunus holsatus, Pagurus Bernhardus, Mysis spiritus, Themisto Dickieana, Crangon vulgaris,* and fragments of stalk-eyed crustacea beyond identification; *Amphidotus cordatus, Ophiura texturata, O. albida,* numbers of small vermin-form bodies which may be the cirrhi of the *Ophuridæ* which always accompanies them, or perhaps the tentacula of *Amphidotus cordatus.* Fragments of shells, amongst which was a valve of *Psammobia Ferroensis,* sand, fragments of *Echinidæ.* As an article of food this species does not command a ready sale, yet it is a very good article for the table.

THE TURBOT; "Roden Fluke." *Rhombus maximus* (Cuv.).

"In an example taken at Torbay, which Mr. Gosden, of Exeter, examined, he found *Xantho florida, Gonoplax angulata, Portunus puber, Porcelanus longicornis, Galathea squamifera, Stenorynchus phalangum, Ophiostrix fragilis,* and *Eurynome aspera*" ('Land and Water,' January 17th 1880).

"Pontoppidan remarks that it feeds on young crabs and small fish, sea-eggs or sea-urchins, of which it is very fond" (Day).

"Crabs and shell-fish also form part of its food, and indeed it appears that little which has life is rejected" (Couch).

Food: "Insects and worms" (Bloch).

Hitherto this species has been caught along the north-east coast of Scotland, during spring, with what are termed "great lines;" now, however, they are brought in all through the year by steam trawlers, their general length being about two feet, but I have measured them over two and a half feet. In the stomachs of thirty-two examined were herrings, whitings, sand-eels, and small *Clupeidæ*; fish scales, *Crangon vulgaris*, and often pieces of fish too much digested for identification. This species is terribly infested with tape-worms, which generally lie along the intestine and sometimes in the stomach. I have never seen one without them.

THE WHIFF. *Arnoglossus megastoma* (Day).

In one "Thomson found a *Callionymus dracunculus* three inches long, and three small *Gadi;* in a second three examples of *Merlangus vulgaris* three inches long; in a third only shrimp-like crustacea" (Day).

This fish has been looked upon as a rarity on the coasts of Scotland, hitherto only an occasional one having been landed by line-fishers. Now, however, it is brought in in considerable numbers by steam trawlers. Their food, so far as I have seen, consists of small haddocks and whitings. It is a fairly good article of food.

THE PLAICE; "Plash Fluke." *Pleuronectes platessa.* (Linn.).

"The smallness of the mouth and structure of the teeth confine it to the smaller and softer inhabitants of the ocean for food" (Hamilton).

"Feed on the soft-bodied animals generally, with young fish and small crustacea" (Yarrell).

"Thomson found *Tellina tenuis*, fragments of *Mactra solida* and *Mytilus edulis*, *Aphrodita aculeata*, portion of

Buccinum undatum, with the remains of decapod crustacea, *Lucina radula*" (Day).

This species is held in high esteem in London and other parts of England, not so along the north-east coast of Scotland, where it has not been largely taken until the advent of steam trawlers. By them it is the principal fish caught. I have seen 120 boxes brought in by one steamer, each box containing about twenty fish. In the stomachs of thirty examined, there were on June 26th *Venus Gallena, Mysis spiritus, Pleurotoma turricula, Nucula nitida.* June 27th, sand-eels and a number of small *Hilothuriadæ* (?). August 31st, a number of small annelids, also much matter composed of weed, sand, mud, hair, and fragments of shell. September 22nd, annelids and sea-weed. October 6th, mollusca denuded of their shells. December 1st, annelids, bits of straw, small twigs of wood, and fish scales.

THE LEMON SOLE; "Lemon Dab." *Pleuronectes microcephalus* (Donovan).

"They feed on shell-fish and crustacea. Thomson found a *Nereis* in one" (Day).

"It feeds on small shell-fish and crustacea" (Parnell).

"It is probable that the usual food is either vegetable or of the smaller sea insects (*Entomostraca*)" (Couch).

This fish does not readily take the hook, as we may assume from the fact of its being seldom brought to market by line-fishers. Hitherto it has not been known as abundant on the north-east coast of Scotland; we are therefore indebted to trawling for the proof that it is by no means uncommon in that quarter, they being caught by that mode of fishing in fair abundance; every voyage there are some brought in. I have seen over two hundred for one haul. Fragments of shell and annelids are all I have yet found in their stomachs; amongst the latter *Nemertis Borlasii* is, I think, present.

THE POLE OR CRAIG FLUKE; "Witch Sole" (Aberdeen). *Pleuronectes cynoglossus* (Linn.).

"In the winter months they inhabit rocky ground, and feed on different kinds of crustacea. In the stomachs of those examined were found the remains of small crabs and star-fish" (Parnell).

"Its food consists of *Gadi minores, Scorphii, Ammodytes, Salmo arcticus, et cancri varii*" (Fabricus).

The above are the only two authors I know who say anything of the food of this species, which has hitherto been accounted rare in British waters. It is a species that does not take a bait very readily. During a space of twenty years' observation I had only seen three individuals brought into the port of Aberdeen. Within these twelve months past, however, they have been caught in considerable numbers by trawl steamers; from twenty to sixty being no uncommon number for each vessel, and it is rare to find that they have none. On the morning of February 23rd 1883, I counted one hundred and forty-five upon the trawler *Bonito* alone; and these were accompanied by a third of that quantity of the whiff. Although this fish is thin, and wants altogether the fine plump appearance of the plaice or lemon dab, yet as an article of food it surpasses both; a better flavoured fish cannot be obtained or one more easily digested. Had Quin been acquainted with this fish, there is little doubt he would have forsaken his favourite dory and feasted on the craig-fleuk instead. Still, this fish does not bring a high price in the market, on account, I believe, of its lean appearance; once tasted, however, its quality is known and duly appreciated, as can now be testified by many in this neighbourhood under whose notice it has been brought, the consequence being that it is steadily obtaining a better position in the market. Many of them attain a length of from twenty-four to twenty-six inches. They are laden with spawn in February. Its food consists (as ascertained from seventy-one examined) of *Aphrodiata aculeata*, annelids, *Priapulus caudatus* (?), *Crangon vulgaris*, *Portunus pusillus*, *Anoyx denticulata*, *Diastylus bicornis* (?), *Diastylus* (?), *Pagurus ulidiamus*, *P. Bernhardus*, *Philine scabra*, *Solen pellucida*, *Tellina pusilla*, *Ophiura albida*, *O. texturata*, *Ophiocoma filiformis*, fragments of shell with bits of fleshy matter, which in all likelihood are the molluscs which occupied these shells, also fragments of sessile-eyed crustacea. The matter in the stomachs of these fish is generally, so far as I have yet seen, of a dark muddy appearance as if it were disintegrate peat, and amongst this substance the forms above named are found. This dark matter (some of which is shown in the collection of material accompanying this paper) would indicate that the fish seeks its food on soft oozy ground. The chief food is *Philine scabra*; whatever else may be found in the stomach this lovely little mollusc is always present.

THE COMMON DAB; "Sattie." *Pleuronectes lemanda* (Linn.).

"The dab feeds on small fish, crustacea and marine insects" (Yarrell).

"It feeds on small fish, crustacea and shell-fish" (Hamilton).

"Crustacea and small fish appear to be their principal food" (Parnell).

"It feeds on marine worms and small crustacea. Thomson found in the stomach of one fragments of one of the bivalve shells, *Solen*, and of corallines, among which *Sertularia dichotoma* was apparent. Johnston remarks that off Berwickshire its favourite food appeared to be the *Pecten obsoletus*" (Day).

"It feeds on marine worms, crustaceous animals, and small shell-fish" (Couch).

This is a very abundant species along the north-east coast of Scotland. The number examined by the writer 123, with the following result: Sand-eels, young *Clupeidæ* roe (not known), *Portunus holsatus*, *Pagurus Bernhardus*, fragments of small crabs, *Hyas coarctatus*, *Crangon vulgaris*, *Dexamine Vendlomensis*, *Ophiura texturata*, *Ophiocoma brachiata*, *Scrobicularia prismatica*, *Nucula nitida*, *Mactra stultorum*, *Tellina fabula*, *Solen pellucidus*, *S. siliqua*, *Venus facsiata*, *Cardium echinatum*, *C. edule*, *Pleurotoma turricula*, *Tornatella fasciata*, *Natica Alderii.* It is quite possible that the three last named had been occupied by young hermit crabs; some of them did contain hermits; *Pecten tigrinus*, molluscs, as also their shells, were often present, which it was impossible to identify owing to their mutilated condition. Anemones, corallines, seaweed, sponge (?), chips of wood, *Echinocyamus pusillus*, zoophytes (?), small round bodies which may be anemones, or perhaps fragments of *Holothuridæ*, sand, *Amphidotus cordatus;* objects not known; each was imbedded in soft, pulpy matter. Being generally of small size, this fish, although very good, is not held in great esteem for the table.

THE FLOUNDER; "Beggar Fluke," "Freshwater Fluke," "Salmon Fluke." *Pleuronectes flesus* (Donovan).

"Aquatic insects, worms, and small fish are the ordinary food" (Hamilton).

"It is a greedy and voracious feeder, eating worms, slugs, crabs, young fish and animal substances. Thomson found in one he examined in Belfast, the remains of *Rissoa ulva;* and Johnston, of Berwickshire, obtained from them *Pecten obsoletus*" (Day).

"The flounder feeds on aquatic insects, worms, and small fish" (Yarrell).

"In general it is a dirty feeder, subsisting on slugs, worms, and dead animal matter" (Parnell).

"Gives a preference to harbours into which a river flows, and which it traverses with the tide in search of worms or crustaceous animals" (Couch).

Of this species twenty-eight have been examined, and the stomachs of these contained *Pagurus Bernhardus, Portunus holsatus, Corystes cassivelaunus, Diastylus borealis* (?), *Atylus Swammerdamii,* sessile-eyed crabs not known, *Nucula nitida,* fragments of shell, annelids, vertebræ and intestines of small fish, *Ophiura texturata,* bits of wood, sea-weed, straw and mud. This is an abundant species in my locality, and commands a ready sale, although not a high price. It is a fish of good flavour.

THE ANGEL FISH.

"This fish is very voracious, and feeds on the smaller flat fish" (Yarrell).

"Preys on small fishes, principally on the smaller kind of flounders" (Parnell).

"One had in its stomach twenty-eight opercula or head covers of whelks, also fragments of small fishes and two stones about the size of nutmegs" (Couch).

"Feeds on flounders and flat fish" (Pennant).

Within my district this species has only occurred once during a period of over twenty years' observation, viz. on January 20th 1883; its stomach contained remains of haddock. This species is a coarse article of food.

GREY SKATE; "Dinnan." *Raia batis* (Bloch).

"I found in one a fishing frog or angler that weighed upwards of six pounds; in another, two large plaice; a lobster; a couple of mackerel; thornback ray, about eighteen inches in length, and half a salmon" (Couch).

"Lives upon whatever living animals they can surprise, or whatever putrid substances they can meet with" (Cope).

"They are very voracious, feeding on other fish and crustacea" (Hamilton).

The grey skate is a common species in my locality, and is caught in great numbers. In thirty-one examined the stomachs contained small whitings, *Crangon vulgaris*, *Pandulus annulicornis*, *Palæmon* (?), starry ray, small cuttle-fish, *Atelecyclus heterodon*, *Galathea* (?), *Portunus holsatus*, herring, small flat fish. In almost every case the stomachs contained numbers of *Crangon vulgaris*, which seems to be their chief food.*

THE HOMELYN RAY; "Eel-pot." *Raia maculata* (Montagu).

This would appear to be the *Raia miraletus*, cuckoo ray, of Couch. There exists some strange difference of opinions amongst authors with regard to this fish which it is difficult to clearly understand. No writer whose work I know says anything as to the food of this species. It is quite abundant at Aberdeen and elsewhere along the north-east coast, but never attains a large size. Its food (so far as my observation extends) is *Crangon vulgaris*, annelids and *Mysis chamæleon*, and as in the case of *R. batis*, *Crangon vulgaris*, that is, the common shrimp, is its chief article of food.

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* April 27th.—Found, in the stomachs of some grey skate, to-day. [illegible]d the eggs of some of the rays.

Raia miraletus (Donovan).

Described as the "Spotted ray" by Parnell and Couch; "*Leechie*," Aberdeen.

This species, if species it is, is not so abundant as the two foregoing, yet quite common. In the stomachs of twelve examined were *Crangon vulgaris*, *Portunus holsatus*, *Themisto Dickieana*, and annelids, with *Crangon vulgaris* as in the rays already named.

THE STARRY RAY. *Raia radiata* (Donovan).

Dr. Parnell observes, "This beautiful little skate, which appears the smallest and best marked species of the genus, was figured and described by Mr. Donovan from a small specimen taken somewhere off the north coast. It has since been found by Dr. Johnstone in Berwick Bay, and by myself several times in the Firth of Forth, but no other localities have yet been discovered."

Couch, who wrote in 1864, says he never saw but a dried skin in the possession of Mr. Yarrell, and he copies Donovan's plate. Nothing is said by either of the above named, or any other writers that I know, as to its food. This species takes a bait readily, and is brought to Aberdeen market by line-fishers in considerable numbers during summer. By trawlers it is brought to land by hundreds at all seasons of the year. By the examination of forty-five examples I find its food to consist of whiting, sand-eels, *Goby*, small flat fish (in every case beyond recognition specifically), herring fry. On December 22nd 1882, in five examined, the stomachs were crammed with young haddocks, *Crangon bispinosus*, *C. vulgaris*, *Pagurus Bernhardus*, *Portunus holsatus*, *Themisto Dickieana*, *Mysis spiritus*, annelids. Chief food, *Crangonidæ* or shrimps. This species never attains a large size, eighteen inches over all being the maximum length. It is good for the table, but on account of its diminutive size does not command a high price.

Here ends my list, imperfect as it necessarily is, yet I trust it may be found to accord with the rules laid down by the promoters of the Exhibition; and further, it is to be hoped that within the foregoing pages something may be found to have been added to our knowledge of the subject which has been under consideration.

As stated at the outset, the importance of this line of research is only now dawning upon us, and we are already much behind other nations, as witness, for example, what is being done by America. This is no mere fanciful question, interesting only to the scientific student; it is one of importance as connected with the question of food supply. It is therefore a duty incumbent upon every one who can, to add his mite of knowledge to the general stock. It is a matter of national interest, and that being so, it becomes a national duty that we work the question out. It is also the basis on which all our real knowledge of fishes should, nay, must rest; it is also the point from which a start must be made in our endeavour to ascertain the true history and habits, and what influence it has, if any, upon the movements, i.e. migrations of this interesting and highly useful class of beings.

As already hinted, America holds first place in this enquiry, and by its "Fish Commission," conducted by Professor Spencer Baird, 100 new species of fishes have been added to the American list within the brief space of twelve years. In following out this line of research along the American coast Professor S. Baird "considers it necessary not only to know the life histories of the fishes themselves, but also that of the plants and animals on which they feed, as well as the histories of their enemies and friends." This is the true method of investigation, as the brilliant achievements already attained by the Americans incontrovertibly prove. Let us, then, have a similar organization inaugurated, with properly qualified practical men to conduct it, of which there are many in our country, and there is not a shadow of doubt but that the result must be a thorough knowledge of the vertebrate and invertebrate animals which inhabit our seas, as also a corresponding increase to the food supply of the nation. In confirmation of this belief, it may be stated that only in 1870 and 1871 the Americans discovered a species of fish new to science, viz. the "Tile" (*Lopholatilus chameleonticops*), a fish weighing from five to sixty pounds, and "in abundance for one thousand miles along the eastern edge of the gulf stream," and is "in numbers equalling the cod-fish" and is a "magnificent food fish." Now when a fish of such size and numbers has been overlooked, occurring as it does in the "very thickest path between Europe and America," is it impossible that such a find may not yet occur in our own seas? Another point in this subject which may be briefly adverted to is, that at present there are hundreds of inland lakes in our country, covering thousands of acres of land, which are almost useless, pre-eminently so in Scotland, but which might be turned to great practical use, were these lakes stocked, as they might be, with the "shoodic" salmon of America and such like, this being a species which does not require to make a periodical journey to the sea. If such experiments are to be attempted, our first duty is to learn what is the food of this and kindred forms; second, to find if such food exist in our lakes, and if not, if it can be introduced. With these points satisfactorily disposed of, there is little reason to doubt but that the undertaking would be a success, and the advantage gained enormous. Let us then make ourselves thoroughly acquainted with the food of fishes, beneficial results must unquestionably be the natural sequence.

THE
CURRENTS, TEMPERATURES,
AND OTHER
PHYSICAL CONDITIONS OF THE SEA
IN RELATION TO
REPRODUCTION, GROWTH, AND MIGRATIONS OF FISH.

"*ALIQUIS*."—[W. WATT.]

ON THE CURRENTS, TEMPERATURES, AND OTHER PHYSICAL CONDITIONS OF THE SEA IN RELATION TO REPRODUCTION, GROWTH, AND MIGRATIONS OF FISH.

THE western shores of these islands are washed by the great north-easterly current or drift of the Atlantic known as the Gulf Stream, to which, as is well known, we are indebted for a geniality of climate, especially on our western coasts, such as is not elsewhere enjoyed in similar latitudes. The Gulf Stream is part of the general oceanic circulation of the globe. It may be traced all the way from the Indian Ocean. From the regions of the South Atlantic, near the western coast of Africa, it follows the north-westerly trend of the land, passing into the Caribbean Sea, thence sweeping round the Gulf of Mexico, and rushing through the Straits of Florida as a great contracted river, 30 miles broad, and 350 fathoms deep, with a velocity of 4 miles an hour, and a temperature of 85° Fah. The stream is continued north-eastward at first nearly parallel with the American coast. As the flow is continued the warm stream becomes outspread, its temperature lowered, its speed slackened, and portions of it are separated and deflected from the main course. The prevalence of south-westerly winds, and the natural effect of the rotation of the earth on its axis serve to maintain the north-easterly flow after the original impulse has abated. The stream is continued past the British Islands into the sea between Iceland and Norway, where its speed, it has been calculated, does not exceed 1½ to 2½ miles a day, and on to the Arctic regions about Spitzbergen, where its presence has been manifested by the casting ashore of West Indian seeds. Even in those high latitudes it is still appreciable as a distinct and moving current. On the eastern side of Spitzbergen its course appears to be changed by some blocking or modifying agency. Here it was found to carry the Austrian exploring ship *Tegethoff* towards the north-west; and Mr. R. H. Scott, the secretary of the Meteorological Council, in a work just issued, records the discovery, in 1881, on the coast of Labrador, of glass fishing-net floats, of a pattern used only by Norwegian fishermen, and which, it would seem, must have been washed away from the coast of Norway, and have made the circuit round the north of Spitzbergen and along the Greenland coast to the spot where they were found. It thus appears that a portion of the warm Gulf Stream becomes lost in the ice-cold Labrador current which skirts the American shore and passes southward beneath the heated river that flows into the open Atlantic from the Gulf of Mexico.

Of the Gulf Stream a feeble wave passes up the English Channel and through the Straits of Dover; its volume, force, and warmth, however, being insufficient materially to affect the general temperature of the North Sea, or to affect it at all except within a limited area at the extreme south. By the deep-sea explorations carried out by the *Lightning* and *Porcupine* in 1868, 1869, and 1870, under the scientific direction of Dr. Carpenter, Mr. Gwyn Jeffreys, and the late Sir Wyville Thomson, it was established that along the western side of Ireland and the Hebrides the heated water, some little distance out, has a thickness of some eight hundred fathoms. A portion of this warm water washes the shores of Orkney and Shetland, and curves round into the North Sea by the Pentland Firth and the channels between these islands. Thus it comes about that the surface water of the northern section of the North Sea is during winter and early spring higher in temperature than that of the middle and southern sections.

To counterbalance this north-eastward flow of heated water from the tropics, there is believed to be a constant creeping southward, in the depths of the sea, of water from the Arctic regions. This southward movement proceeds very slowly, and receives the name not of a current, but of an "indraught." The late Sir Wyville Thomson, a man of unique experience in deep-sea exploration, spoke of the investigation of the currents in the neighbourhood of the British Islands as being attended by "singular difficulty." Surface currents are often easily detected, but other oceanic movements of the greatest importance, involving the transfer of enormous masses of water, are so sluggish in their operation, and so liable to be masked by the drift of variable currents, that their course and progress cannot be traced.* We have, however, the broad fact that all over the ocean, even under the equator, below a certain depth, there is a great substratum of water of about the temperature at which fresh water freezes (and not 39·5° Fah. as was once supposed). Beneath the Gulf Stream, in situations where the ocean deeps are uninterrupted by shallows, the two strata are well marked—that of the surface exceptionally warm (for the latitude), that of the bottom of icy coldness. Dr. Carpenter reports[*] that at one sounding station near Faroe it was found that the thicknesses of the two strata were nearly equal, each being about 2000 feet, "the lower an Arctic stratum flowing in a south-westerly direction beneath the upper stratum of comparatively warm water moving towards the north-east."

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* 'Depths of the Sea,' p. 361.

One reason for believing that there is a southward indraught of water from the Arctic regions is found in the distribution of Arctic fauna. Reasoning as a naturalist, and with the results of a most extensive series of dredging operations before him, Sir Wyville Thomson concluded that "there is a direct movement of cold water from the Spitzbergen Sea into the North Sea."[†] The North Sea slopes to the north, becoming gradually shallower towards the south. There is great abundance of animal life in the Arctic regions, and great abundance of Arctic types of life in the deep water in the neighbourhood of the Shetland Islands.[‡] The influence of the indraught of cold water from the north becomes less and less apparent as we proceed southward towards the shallower waters between Scotland and Denmark. By the time we reach the Dogger Bank the northern fauna has entirely disappeared. On the western side of the British Islands, however, northern species are to be found down to and beyond the southern limit of the British area. For this reason Sir Wyville Thomson suspected that the water of the Gulf Stream amalgamated, before touching these islands, with a portion of the northern water. "Since 1860," he wrote,[§] "I have been led to suspect that a portion of the Arctic water oozes down the Scottish coast, much mixed and sufficiently shallow to be affected throughout by solar radiation. About 60 or 70 miles from shore the isothermal lines have a slight but uniform deflection. Within that line types characteristic of the Scandinavian fauna are numerous in shallow water, and in the course of many years' use of the towing-net I have never met with any of the Gulf Stream Pteropods or of the lovely Polycystina and Acanthometrina which absolutely swarm beyond that limit." In further corroboration of his suspicion Sir Wyville added that the difference in mean temperature between the east and west coasts of Scotland, amounting to about one degree Centigrade, was also somewhat less than might be expected if the Gulf Stream came close to the western shore.

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[*] Proc. Royal Society, xvii. p. 441.

[†] 'Depths of the Sea,' p. 112.

[‡] See Reports of British Association, 1862–68. Reports by Mr. Gwyn Jeffreys, Rev. A. M. Norman, &c.

[§] 'Depths of the Sea,' p. 400.

On the other hand we have the significant fact that southern species travel northward by the western and rarely by the eastern sea. They are to be found along the whole western coasts of Ireland and Scotland, in the Moray Firth, at Orkney and at Shetland; but sparingly in the more southerly latitudes of the east coast of Scotland, and more sparingly still in the latitude of Yorkshire. This is especially true of crustaceans, and these facts as to their distribution seem to leave no doubt as to the route by which they have travelled.*

Currents influence the distribution of marine life in two ways: (1) by acting as means of transport, and (2) through temperature. When there is a decided flow or set of water in one direction it necessarily carries with it a great many floating objects. These may include the incubating ova of fishes and invertebrata, the free-swimming larvæ of innumerable species, and even, to a certain extent, the adult [illegible]bers of these species, when they are free swimmers,

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[illegible]are Rev. A. M. Norman, British Assoc. Report for 1868.

though the movements of adults are greatly affected by the pursuit of food. Fishes when inactive may be floated along by a current, but it is a well-authenticated trait of fish life that they turn themselves against the stream in order to feed upon the organisms it bears along. And a warm or cold current passing through water of different temperature is an extension of the warm or the cold area, as the case may be. With this extension of area we may look for an extension of its appropriate fauna.

Of currents as means of transport I have already given the illustration of West Indian fruits cast ashore at Spitzbergen, and of glass floats apparently conveyed from Norway to Labrador by way of Spitzbergen and the eastern side of Greenland. Further illustrations might be drawn from the every-day experiences of nautical life. Thus Rennel's current, turned northward at Cape Finisterre and westward at Ushant, sends ships entering the Channel so far out of their reckoning that in fogs they are apt to strike on the Scilly Isles. Other vessels, sailing from Liverpool, have their reckoning and the guidance of the compass overborne by the drift of surface-water, and are driven aground at the south of Ireland. Along the whole of the British coasts there are currents more or less variable and of greater or less velocity, those on the west side having in general a northerly flow, and those on the east side accompanying the tidal flood-stream towards the south. Then, again, there are the surface currents produced by winds, now drifting towards the land and bringing the floating ova and larvæ of marine creatures from the deep sea to the shores, now acting as forces of dispersal conveying great masses of germinal existence out to sea. In this way species are diffused as widely as the climatal conditions of their existence. Myriads of the larvæ of shore molluscs are thus carried far from their proper habitat and perish, and not of molluscs only but of the general fauna of the littoral and laminarian zones. Echinoderms, on the other hand, which dwell in Forbes's coralline zone (fifteen to fifty fathoms), suffer by being transported into shallower water with its greater extremes of temperature. Deep-water species have no doubt, on the whole, a better chance of passing through the larval and free-swimming stage in safety than the species of the shore. The deep sea is far greater in extent than the littoral fringe, and the chance correspondingly stronger, that when the free-swimming career is exchanged for a sedentary life in the depths, the descent will be made in a suitable locality. No accurate estimate has ever been formed of the power of currents as agencies of transport and distribution. But we know that the great Labrador current, for instance, transfers from north to south enormous quantities of Arctic forms of life in the early stages of their existence. The "Grand Banks" of Newfoundland teem with this life at certain periods of the year, affording an inexhaustible supply of food to the cod by which these banks are frequented, and to the shoals of smaller fishes that are the prey of the cod. In our European seas, and especially in those around the British Islands, the mutability of surface currents makes it almost impossible to trace out their path over any wide area of ocean, but some broad facts bearing on fish life may be clearly traced.

There are to be found on the coasts of England, France, Holland, and Germany, every spring, great quantities of young flat-fishes. These fry are met with in extremely shallow water, in rock pools, and on sandy beaches. Obviously they must have been transported thither as eggs or as larvæ by the action of the sea. There are none of the adult fish in such places, and few may be caught within miles of localities where the fry are abundant. On the low-lying coasts of Hanover and Holland the larval flat-fishes have come, there can be no doubt, from the deeper water some distance to the north. Plaice, for example, are known to spawn about the regions of the Great Fisher Bank, and the east end of the Dogger. From these regions the ova appear to be carried southward by currents, and when the larvæ are hatched out they are close to the shore. So it is with other flat-fishes. They are carried towards the land by surface currents, either as embryoes, or as larvæ. And not with flat-fishes alone, but all other fishes produced from floating eggs. It is a rule to which there is no known exception, that fishes have in their first days a period of pelagic life at the surface of the sea. This rule applies equally to the herring, which comes from an egg that has undergone the process of incubation on the sea-floor, and to the turbot or plaice whose eggs float in the water. The herring is permanently a surface-swimmer; the turbot and plaice soon descend to the sea-floor, there to pass the remainder of their days. As larvæ they are all equally surface-swimmers. The south-west of England intercepts and divides an outlying portion of the Gulf stream. It also meets the prevalent south-westerly winds of the Atlantic that in their degree guide or intensify the drift of the current. We should naturally expect that great masses of living organisms would be transported by these influences to the Cornish coast; and such, in point of fact, is the case. The great pilchard shoals are attracted thither by the abundance of larval and crustacean food which they find; this food they follow even into the bays and creeks, where they are enclosed by seine-nets and captured *en masse*.

But the currents of the sea, especially those created by winds, do not always bear in the direction of land so near as to be within reach. Sometimes the gale blows directly away from the land, in which event objects floating at the surface, even objects so minute as fish eggs and larvæ, would be carried out to sea. That multitudes of young fishes as well as of molluscs are destroyed in this way seems tolerably certain. Far out at sea, and floating at the surface, are found curious creatures called Leptocephalids. They are quite transparent, with cartilaginous skeletons, never sexually mature, and bear all the marks of development arrested at an early stage of life. Dr. Günther concludes* that these Leptocephalids are the young of shore fishes whose spawn has either been shed far out at sea or carried thither by currents, and that when thus removed from the natural conditions of their existence the young "grow into undeveloped hydropic creatures such as the Leptocephalids appear to be." Many of them seem to be the young of the conger, which is pre-eminently a shore fish. The same kind of arrested or abnormal development is seen in flat-fishes also taken at the surface of the open ocean far beyond the limits at which flat-fishes exist at the bottom. There would seem to be no doubt that these hydropic surface-swimming *platessæ* have been carried out to sea by currents. On descending into the water they may have gone far beyond their natural depths, and still finding no floor, no resting-place or means of subsistence, have returned to the surface to languish out a miserable career. Within the geographical limits of the several species of marine animals that spring from floating eggs or larvæ, currents serve as an agency of dispersal and means of distribution. This rule applies not only to fishes themselves, but to nearly all forms of invertebrate life constituting the supply of fish-food—to annelids, crustaceans, most molluscs, echinodermata, sponges and polyps. When they are carried beyond their geographical limits they perish.

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* 'Introduction to the Study of Fishes,' p. 181.

There is every reason to believe that the migrations of herrings in the North Sea are partly governed by currents, through the distribution of food, just as the migration of cod at Newfoundland is directly traceable to the effects of the Labrador current. At all events, the coast waters which have a general southward motion are resorted to by the great summer shoals. And if it be the case that currents are a main agency of distribution with respect to marine invertebrata, it follows that indirectly, through food, they also determine the distribution of fishes.

Let us next consider the effects of temperature. Currents are an agency in the distribution of temperature as well as of animal forms. Warm water has a fauna of its own, cold water another and entirely distinct fauna. The former, as we have seen, is brought to these shores by the Gulf Stream; the latter by the great submarine indraught from the Arctic regions. The surface temperature of the sea is also affected to some extent by the temperature of winds. Mainly, however, it is determined by the direct heat of the sun. Accordingly, surface-temperature varies with the seasons, while the temperature of the depths is uniform throughout the year. In temperate regions the heat of the sun does not penetrate many fathoms, and as the heated water is of less specific gravity than the cold water below, it remains on the surface as a distinct stratum, not sharply defined, but gradually merging in that on which it is superimposed. Mr. Scott, of the Meteorological Office, in giving a general account of the sea surface-temperature round the British Islands for the months of February and August, states * that in February the

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* 'Elementary Meteorology,' 1883, p. 319.

temperature never reaches 50°, but closely approaches that degree at the entrance of the Channel, ranges about 45° round Ireland, and does not much exceed 40° on the east coast, from the Thames to Shetland. In August the temperature round Ireland is about 55°, and in the Channel and southern part of the North Sea as far as the Wash about 60°, while along the remaining British coasts the mean is again about 55°. Thus it appears that in the track of the Gulf Stream the variation between the summer and winter temperature is only about 10°, whereas on the East Anglian coast it is 20°, and on the east coast of Scotland 15°, all of the Fahrenheit scale. The physical conditions of the North Sea were thoroughly investigated some twelve years ago by a German Commission headed by Dr. H. A. Meyer, of Kiel, for which purpose the Government vessel *Pomerania* was placed at their disposal. The results of these investigations, as regards temperature, were to this effect:—In January the surface temperature is highest in the extreme south and in the north by reason of the Gulf Stream waters poured in through the Straits of Dover and by the Orkneys, while on the German coast it is exceptionally low on account of the masses of water bordering on freezing point received from the Rhine, the Weser, the Elbe, and the Baltic. This state of things continues till April, in which month the temperature of the coast waters begins to rise. The rivers warm as summer approaches, and during July, August, and September, the southern parts of the North Sea are considerably warmer than those farther north. In April, May, and June, when the coast temperature is gradually rising, the Dogger remains cool, and after the beginning of October the cooling process sets in rapidly on the German coast until the state of matters that existed at

the beginning of the year is restored.[*] Generalising
observations still further, it may be stated that in w
with the exception of a small area near the Stra
Dover, the shallow southern part of the North Sea is c
while the surface waters of the north are relatively w
whereas in summer the southern waters are warm an
northern surface waters relatively cold. The temper
of the northern part of the North Sea is much more eq
than that of the southern part.

It was held by naturalists so experienced and obse
as Edward Forbes and Sir Wyville Thomson that th
tribution of marine animals is determined almost exclu
by temperature. Currents act as means of transpor
temperature fixes the limits of habitableness. Now, it
curious fact that all our great fisheries are fisheries o
cold water. The cod fisheries of Loffoden, of Icela
Faroe, of Shetland and of Newfoundland are all carri
in water from the Arctic Ocean. The Dogger, Great Fi
and Well Banks are by no means warm places, especia
the cod season. The principal herring fisheries are ca
on in the northern half of the North Sea. Trawlin
flat-fishes is prosecuted more to the south, but it is n
be forgotten that the British area altogether is north o
50th parallel of latitude. Our two most southern fishe
the mackerel and pilchard. Farther south the fish
are comparatively unimportant, and the fishes so
texture and insipid to the taste. So likewise in the Pa
the best fisheries are those of China and Japan, of
Russian dominions, Alaska and British Columbia an
portion of the western sea-board of the United St
Marine life is extremely abundant in the coldest water o

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[*] Karsten, in Report of German Commission (trans. in U.S. C
missioner's Report for 1879).

side the limits of Arctic ice, and also extremely varied. Small free-swimming crustaceans and pteropods are met with on the borders of the Arctic regions in such quantity as to form the sustenance of the whale. Gadoids are abundant at Spitzbergen and in the cold water that oozes into the North Sea between Shetland and Norway; cod, ling, torsk and halibut are found there in the greatest perfection both as to size and quality. Arctic molluscs, crustaceans and echinoderms are to be met with on the Shetland "Haaf" in the utmost profusion. Great marine arachnids and other characteristic boreal forms contribute their quota of food to the rapacious and thriving shoals of large and powerful fishes that flourish in those seas. These Arctic forms of life, it is believed, are being constantly reinforced by new arrivals from deeper waters and more northerly latitudes, the surface water of Shetland being probably too warm for their larval development at the free-swimming stage. At all events fishes of the Gadoid family are large, well fed, and of excellent quality in the deepest waters of the North Sea; and near the surface of the same waters, heated to a certain extent by the warm Gulf Stream, vast shoals of herrings live and thrive in the highest perfection.

Sir Wyville Thomson was of opinion that distribution of marine animals was probably determined by extremes of temperature rather than by means. The extreme cold of winter in the southern part of the North Sea as contrasted with the heat of summer may explain why it is that fishes that prefer moderately warm water, such as the mackerel and pilchard, are not more plentiful there. We have seen that the mean variation of surface temperature in East Anglian waters is 20°, but the extreme variation, especially in seasons of exceptional severity, is considerably greater. In wintars of severe and protracted frost the fauna of the intertidal zone suffers not a little ; and e oysters not subject to exposure by the recession of tide occasionally perish in great numbers. Certain f are also highly sensitive to cold. In times of biting n wind, with very low temperature protracted for d congers in the genial waters of the south-west of Eng —both north and south of Devonshire—have been f in shoals floating helplessly numbed on the surface o water. Surface-swimming fishes at such times take re in comparatively deep water beyond the range of th meteorological fluctuations. During the winter sea mackerel in the English Channel swim near the gro and in the deeper water of the Atlantic they may be from the bottom, but at all events do not present th selves at the surface. The movements shoreward pilchards are delayed in the storms of a protracted win The Scotch winter herring swims low in the water, a thus takes refuge from the wintry gales and frosts. Gadoids, this sensitiveness to cold has, probably with ju been attributed to the southern whiting. The appar delay of the cod in presenting itself on the Norw banks, of which Professor G. O. Sars has taken note possibly due to the action of cold and stormy weath not directly on the cod itself, but on the surface fauna which it feeds. If the small Clupeoids that constitute large a part of the food of cod are prevented from em ing from deep water the cod has no occasion to change ground. And as he is accustomed to ice-cold water in t depths there is no obvious reason why he should sh back from the cold of the surface. In the shallow parts the North Sea the flat-fishes which there abound retire very severe seasons into the deepest water they can find Great Silver Pit and other hollows of like charac near the coasts of Lincolnshire and Norfolk. In shallow water of less than twenty fathoms the effects of storms would be considerable even at the sea-floor, but in the deeper water of the "pits" the conditions would be much nearer those of a normal season.

It is the sole that chiefly shows this sensitiveness, and the sole is a fish hardly to be met with in the colder and deeper water of the Scottish section of the North Sea. Next to the surface fauna the ground fishes of the shore exhibit in the greatest degree this sensitiveness to cold and storms. In deep water there is protection against extremes or even serious changes of temperature, and also against the fury of the gale.

Low temperature has been supposed to retard the spawning of fish. If, however, for the reasons connected with surface food just indicated, the shoreward movement is delayed, all that can be said with certainty is that the spawning fish are not met with so early as usual. Food is no doubt obtained in greater abundance when compressed into a smaller thickness of water, and it is possible, of course, that the superior nutrition of the banks may have an influence in expediting the ripeness of the spawn which is missed when the arrival on the banks is delayed.

The process of incubation is much affected by temperature. The period required for hatching herring ova varies from a week when the temperature is 54° to six weeks when it is 38°. In the case of cod, a range of from thirteen to fifty days has been observed, and so on with other fishes.

Lastly, there are the effects of temperature on the relative scarcity or abundance of food. In this branch of the investigation little progress has yet been made. There is reason to suspect considerable differences from year to year in the supply of surface food—entomostraceans, crustaceans, &c.—corresponding to the differences in the swarms of locusts, flies, and other insects on land. Sometimes the herring shoals find a sufficient supply without coming near the land; in other seasons the shoals approach very closely to the shore. Dr. Ljungman, of Gothenburg, has ingeniously suggested a "secular periodicity" of herring fisheries corresponding with the supposed periodicity of sun-spots and aurora. Certain coincidences of a somewhat striking character are apparently established, but the subject is one requiring a much larger array of data than are yet forthcoming before such a correspondence can be satisfactorily made out. The precise effects of heat and cold on the production of the different marine invertebrates have also still to be determined. The ova of molluscs and annelids have been found in the Baltic at all seasons of the year, but seasonal variations and intermissions of the reproductive process seem to be the all but universal rule, and there is at least probability in the remark of Prof. Möbius, that "the periodical increase and decrease of nutritive matter in the different parts of the sea depend on the degree of warmth and light which during the changing seasons they receive from the sun."

Light is the main or sole cause of the diurnal migrations of the surface fauna. This fauna rises to the surface in the evening, and descends to some depth in the morning. Drift-net fishing operations are conducted at night when the fish have followed their prey to the surface. Within a few fathoms of the surface the light becomes greatly dimmed, and the animals moving about there are as in a twilight. To a zone of dimness, though not of total darkness, the pelagic animals descend at sunrise, emerging again in the shades of evening. During the day the surface of the sea is comparatively void of animal life.

The great rivers that flow into the North Sea affect not only its temperature, but its salinity. From the Elbe, the Weser, and the Rhine on the one side, and the Humber, the Ouse, and the Thames on the other, to say nothing of less considerable streams, an immense volume of fresh water is daily poured into a part of that sea which is of no great depth, and the mass of water is therefore small when compared with that of an equal area farther north. The effect of this great supply of fresh water is to dilute the saline water. Again, a great quantity of brackish water is received from the Baltic, especially in spring and early summer, when the surface ice liquifies, and the Russian, Prussian, and Swedish rivers are all in flood. Accordingly it is found that the salinity of the North Sea is lowest in the shallow parts that fringe its southern coasts. Those parts are principally inhabited by flat-fishes, and flat-fishes generally have no dislike to brackish water. Many of them visit large estuaries, and some even ascend long distances into fresh-water streams. Herrings and some Gadoids can also bear comparatively fresh water without injury. Young herrings, indeed, are often found with sprats in the upper reaches of estuaries, in that of the Forth for instance; and in the West Baltic the older fish live and spawn in water so low in salinity as to be quite drinkable. Baltic species of fish are usually smaller than those of the North Sea, but fishes generally seem to be able to withstand considerable modifications in the chemical constituents held in solution by the water without suffering apparent inconvenience. The food of fishes in estuarine waters differs, no doubt, from that which they find in the sea; and in the flounder, plaice, and others this difference of food produces changes of shape and texture, and deteriorates the quality of the fle The herring of the North Sea is larger in the latitude Shetland than in that of Yarmouth, and the quality, to sa the least, is not inferior. The larger Gadoids also flouri in greatest perfection in the deep, cold, highly saline wat of the North, with their bountiful supplies of crustace and other food. It seems indeed that at the youn stages of fish life the "soft food" of the estuary is m suitable to the condition and growth of many species, b the hardier Gadoids thrive and grow without such he and the Shetland herring is also beyond its reach.

There is still great room and necessity for physical a biological researches into the conditions of fish existen The conditions affecting the distribution of the vari orders of animals that are the food of fishes are still b little known. Systematic observations by many labour and on a common plan are absolutely necessary if rap progress is to be made in this highly important depart-ment of knowledge.

ANGLING CLUBS.

"*CONFIDE RECTE AGNES.*"—[J. SKINNER.]

ANGLING CLUBS.

IT would be impossible in the limited space of an essay to trace the origin of the whole of the angling clubs of the metropolis, but if such information could be obtained it would no doubt be found that the origin of each club arose from one or two causes, namely, the want of some convenient meeting-place to enable anglers to meet together and arrange the time and place for their days' outings, and afterwards to compare the results. A public-house being the most convenient is usually selected for this purpose, the majority of publicans being anxious to increase their trade by the formation of clubs of various descriptions according to the capacity of their premises and the requirements of the immediate neighbourhood. Should, however, the publican himself be an angler, or have a partiality for the sport, the greater encouragement and accommodation he will afford the anglers by placing a room at their entire or partial disposal for the holding of their meetings, for the exhibition of their fish and to exhibit the cases of fish which may have been considered worthy of being preserved, and in many cases by giving prizes, and thus a club will be formed and a day or days of meeting fixed most convenient to the majority of the members. Origin.

Sunday being the only day on which the majority of anglers can enjoy themselves in the country is there the principal day, and a week-day is added for th members who, either from religious scruples or the na of their business or position in life, object to devote t Sunday to their sport.

There are 32 clubs whose meetings are held on Sunda only, 3 on Mondays, 2 on Sundays and Mondays, 7 Sundays and Tuesdays, 12 on Tuesdays only, 9 on Sund and Wednesdays, 26 on Wednesdays, 12 on Sundays a Thursdays, 19 on Thursdays only, 2 on Sundays a Fridays, 5 on Fridays only, 1 on Saturday and Sun and 2 on Saturdays, and there are 12 clubs which mee any and every night.

A club being formed the members are enabled to m together to discuss the past and future prospects of sp and those who are unable to go out can participate the enjoyment of witnessing the sport of more fortu members. The objects of a club are, to keep a record the fish taken, the giving of prizes by the members (ab the advisability of which there is a deal of discussion g on at the present time), the giving of club prizes specimen fish and gross weights, the encouragement true sport and the protection of anglers' interests.

Extent.

There are now about 160 clubs in the metrop numbering nearly 5000 members, and varying in size a cording to the neighbourhood in which they are form or the popularity of the club, or the energy of the memb in introducing friends. There is one club reputed to ha 250 members, several have over 100, and a good many ha 50 members: this is a convenient working size, as it allo of a reasonable number attending on each meeting nig without overcrowding, and it will be found that where club has been very successful and increased in numbe it then becomes inconvenient to the members to meet at the premises originally fixed upon, and leads to the formation of a club elsewhere by some of the members.

It also frequently happens that members moving out of the range of their club into fresh neighbourhoods look about for other anglers, and thus form a club more convenient for themselves.

There is no doubt, however, that the introduction of the privilege tickets of late years has led to the increase in the size and number of clubs, as these tickets being only issued to *bonâ fide* members of angling clubs, there is a certain number who only join a club for the express purpose of obtaining these tickets.

Constitution.

The efficient working of a club requires a Chairman, Vice-Chairman, Secretary, and Treasurer, who is mostly the landlord of the club-house, or some influential member of the club, who receives and is answerable for the funds of the club. Some have a Committee of Management, whilst others have a provision in their rules for the formation of a Committee for any special business that may arise.

In a great many clubs before and after the transaction of business the members amuse themselves with games at draughts, dominoes, or cards, and sometimes singing, and thus an evening is very pleasantly spent. Smoking concerts are now being introduced, also the reading by members of papers on various subjects likely to be useful or interesting to anglers, and should be greatly encouraged, as it is a step in the right direction which cannot be too highly appreciated.

At those clubs where the meetings are held every night a single man can pass a pleasant and inexpensive evening, and thus escape many of the temptations of London life; and there is no reason why clubs should not be formed (for the benefit of anglers who may be total abstainers or those who wish to encourage temperance principles) and held a the coffee palaces whose rooms are used as club-rooms an evening, the promoters of which are trying to impr the morals and tastes of the rising generation.

There are three associations, called the "Central," t "East Central," and the "West Central," formed for t purpose of issuing the privilege tickets to those clubs w may be on their lists, and the clubs on those lists are the habit of making so-called friendly visits to each ot notice of which is received from the association to wh they belong.

There is also an association called the United Lon Angling Associations Fisheries Society, whose object is secure eligible fisheries for the members at a nominal char and also for the culture of coarse fish, both objects be deserving of the support of every angler; and lastly, ther the Anglers' Benevolent Society, held at the New Forester Hall, Clerkenwell Road; but it is shameful to say t society is now only supported by about 900 members. A grand opportunity now arises for the amalgamation of a these associations into one central association, as Mes Geen, Bonvoison and Hoole are now advocating. There a several very powerful reasons for this being done: 1 Economy. Instead of over 150 officers, as there are now a the present time, one set of officers and committee wo be amply sufficient, whilst the saving in printing and posta would be enormous.

2nd, As the anglers are now becoming an importa body, such a central association or head centre is requir to regulate all clubs as to the size of fish, and to do awa with all gross-weight competitions. Another very important thing is to try and improve the behaviour of som of the anglers on their way to, and from, and at the place fishing. Very many complaints have been made by those who have been unfortunate enough to fall in with the rougher element; the language and behaviour of some of the members of angling clubs have been so disgusting that it has prevented many respectable people from joining a club. Now if clubs had a strict rule to exclude all members who are guilty of improper conduct, and cause them to forfeit their privilege cards, it would restrain those men who cannot speak twenty words without an oath of some kind. As fines are so beneficial for this purpose in the club-room, there ought to be some restriction on the behaviour out of the club-room. The head or central association, besides issuing the privilege and fisheries tickets, ought also to make it compulsory for every member to belong to the Benevolent Association.

Another important object could be gained if this amalgamation were effected. Why should not some large hall be taken (and in course of time no doubt one could be built) where the anglers and angling clubs could meet (without the demoralizing influence of the public-house) and discuss their business?

Another thing should be put an end to, that is, the return visits of clubs to each other. What is gained by members of clubs wasting their time and money in such nonsense? If when they met they were to discuss angling matters, it would not be so bad. Nothing of the sort is, however, attempted, the only and principal business is, "Give your orders, gents!" and "Mr. Brown will oblige with the next song!" These meetings are simply for the benefit of the landlord, not for the anglers or angling. Let every member give threepence quarterly for angling purposes, in support of the Thames or Lea Preservation Societies, and another threepence for the Benevolent Fund, then he will be doing good, not wasting his time and money as thousands are now doing.

Benevolent organizations

The members of angling clubs are composed of all classes of society, according to the surroundings of the club, and there is no doubt that the association of gentlemen with the more humbler followers of the gentle art is for the mutual advantage of both, as a gentleman makes himself sociable with the working man, and the working man is improved by association with gentlemen. Should a member meet with misfortune or require assistance, there are none more ready to help him than his fellow members, and this is effected either by a whip round, or collection in the room, or by a raffle, or arranging a ticket benefit at one of the theatres or music-halls, and appealing to other clubs for their support. There is also the Anglers' Benevolent Society before mentioned, of which Thomas Spreckley, Esq., the Treasurer of the Thames Angling Preservation Society, is President, and is doing a deal of good, though in a very limited way. Their funds could be largely increased if it were made compulsory by the angling clubs and associations, that all members should join it; and as the subscription is only 1*s.* 1*d.* per annum, it would be no tax to the members themselves, at the same time benefiting those members who might be unfortunate enough to require it. All claims are to be forwarded by the secretary of the club to which the applicant belongs, accompanied with a copy of the resolution of the club supporting the same, thus preventing those cases of imposition which frequently occur in other societies.

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